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Project AIR FORCE Analysis of the Air War in the Gulf

An Assessment of Strategic Airlift Operational Efficiency

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PREFACE

This report assesses strategic airlift operations during Operation Desert Shield/Desert Storm. The research represents a portion of two larger research projects, one assessing the initial deployment of Air Force assets in Operation Desert Shield, and the other assessing Air Force performance in Operation Desert Storm. It is one of a set that documents the results of a Project AIR FORCE study of the Desert Storm air campaign. Unlike the others in the series, this document also addresses Operation Desert Shield and the period after fighting ceased.

The study began in March 1991 under the sponsorship of the Air Force Vice Chief of Staff. Its objectives are to describe and assess (1) the effectiveness of air missions in Desert Storm at both the strategic and tactical levels in terms of the initial and evolving campaign objectives, (2) the use of airpower as a major instrument of achieving the withdrawal of Iraqi forces from Kuwait and the implications for future Air Force doctrine, missions, systems, logistic needs, force modernization, and research and development (R&D), and (3) the doctrine for planning and executing Desert Storm in terms of the doctrine for joint U.S. and allied operations.

Other documents deal with intelligence support for bomb damage assessment (BDA) and targeting; Command, Control, Communications, and Intelligence (C3I); Central Command Air Forces' (CENTAF's) Master Attack Plan; close air support/battlefield air interdiction (CAS/BAI) operations; the Joint Forces Air Component Commander (JFACC) and air campaign planning; munitions support for USAF aircraft; logistics and other support for USAF tactical

aircraft; composite wing operations; air attacks against the Iraqi army in the Kuwaiti Theater of Operations (KTO); the Air Force rapid response process for streamlined acquisition during Desert Shield and Desert Storm; F-117A operations; effectiveness of smart munitions; and Strategic Air Command bomber and tankers operations.

The report should be useful to Air Force and Department of Defense offices concerned with the use of strategic airlift in Operation Desert Shield and Desert Storm, and the implications for airlift in future contingencies.

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SUMMARY

When President Bush deployed American combat forces to the Persian Gulf on 7 August 1990, he launched the greatest airlift in history. In the next seven months, the Military Airlift Command (MAC) would airlift to the Gulf over a half-million short tons of cargo and almost a half-million passengers. This operation moved ten times the daily ton-miles of the 1947–1948 Berlin Airlift and four times that of the 1973 airlift to Israel. Unlike those previous, primarily logistic airlifts, Operation Desert Shield marked the first major strategic deployment of combat units by air. In the first 30 days of the airlift, MAC transported equipment and personnel for several hundred combat aircraft, the 82nd Airborne Division, elements of the 101st Airborne Division (Air Assault), a Marine Air-Ground Task Force, plus headquarters and support units.

In the main, this unprecedented airlift operation was very successful. Yet by many measures the strategic airlift system did not appear to attain its expected performance level. Daily throughput fell below Central Command's (CENTCOM's) expectations. Utilization rates were a third to a half below planned levels: 5.7 hours for the C-5 and 7 hours for the C-141. The percentage of aircraft available for the C-5 was only 67 percent and for the C-141 81 percent. Average payloads were 12 to 40 percent below planning factors. Such shortfalls suggest that either capabilities are overestimated or that there are problems in operational efficiency.

This study concludes that a variety of factors prevented optimal performance of the airlift system. Some factors were within MAC's control; most were not. The types of problems can be divided into four

categories: planning, aircrew availability, bases, and aircraft performance.

Planning. Operation Desert Shield began without an operational plan or feasible transportation plan. Requirements were defined as the deployment developed and changed frequently as the operational situation evolved. This lack of a stable, reliable requirement in the first weeks of the operation made it impossible to use the airlift fleet efficiently. Exacerbating the problem, automated database processors and procedures often could not reliably keep up with the frequent changes made to the requirements. Some of the apparent shortfalls in capability arose from people outside MAC who did not understand the assumptions underlying planning factors. Therefore, they built plans and prepared loads based on faulty expectations.

Aircrew availability. Roughly half of all MAC's/Air Mobility Command's (AMC's) strategic aircrews is in the reserves. Commonly cited utilization rates assume all these aircrews are available. However, the President did not authorize the call-up of reserves until 16 days into the deployment and then only partially. The Air Force eventually authorized activation of all the reserve crews for the C-5s and three-quarters of those for the C-141. The late and incomplete call-up of reserve crews made it impossible to achieve full utilization of the fleet. Exacerbating the crew shortage was the lack of a stage base in the Southwest Asian theater. This meant that MAC had to use augmented crews—specifically, three rather than two pilots—for the Europe-theater-Europe leg of the mission, where crew duty days routinely reached 24 hours. The lack of a stage base at a time when aircrews were scarce could by itself explain a 20 to 25 percent shortfall in system performance.

Bases. MAC experienced various problems at onload, offload, and enroute bases. Most deploying units were unable to prepare cargo within the time assumed in planning factors, especially when airlifters arrived at a rate of more than one per hour. This difficulty with cargo preparation meant that many missions were delayed or postponed, reducing the utilization rate of the fleet. The relatively few enroute bases capable of handling the airflow made the entire system highly sensitive to any disruptions at those bases, such as weather, air traffic control delays, or ramp congestion. Three enroute bases handled 61 percent of the airflow and, of these, Zaragoza

is now closed and access to Torrejon and Rhein-Main is restricted. Offloads were largely limited to one location: Dhahran International Airport. This limitation constrained the throughput that could be attained and increased the sensitivity of the entire operation to problems there, such as limitations in the fuel system, ramp space constraints, and breakdowns in material-handling equipment. Although other bases were eventually used, Dhahran remained the dominant offload location. At both onload and offload bases, old material-handling equipment proved to be unreliable and frequently caused delays or limited throughput.

Aircraft performance. On average, every Operation Desert Shield/ Storm (ODS) mission was delayed 10.5 hours, with logistics problems predominating. The C-5 in particular suffered from maintenance problems, with 33 percent of the aircraft deemed unavailable, on average (18 percent of those aircraft were unavailable because of maintenance problems), and, of those planes available, an average delay per mission of 9.0 hours because of logistics. This poorer-than-expected reliability of the C-5 significantly reduced its utilization level. It also meant that at certain times during the operation, the C-5 fleet could not meet the demand for outsize cargo capability. The C-141 had a better maintenance record, but its average payload was 26 percent below planning factors. Concerns about fatigue displayed in the inner-outer wing joint of the aircraft resulted in load weight restrictions. In some other areas, apparently poor performance actually reflects sensible operational decisions obscured in broad measures of efficiency. These decisions include Desert Express, medevac withholds, and the use of narrow-body Civil Reserve Air Fleet (CRAF) aircraft for smaller movements.

Implications. The experience of Operation Desert Shield/Desert Storm highlights some key issues for the future. The C-141 is approaching the end of its service life. If the nation wishes to retain the capability to support a deployment of the scale of Desert Shield, it must modernize its airlift fleet. The C-17, if it meets contract specifications, would fulfill that requirement and offer substantially more capability. We estimate that with the 120 C-17s replacing 265 C-141s, the fleet could have deployed at least 30 percent more cargo in the same amount of time as in Desert Shield. It would also have been able to provide enough outsize cargo capability to meet any conceivable demand. Modernization of material-handling equipment with

the procurement of 60K loaders will offer significantly greater reliability and flexibility.

Airlift is a system, and for the system to function efficiently its components must each work well and be kept in balance. The recommendations of this study reflect this fact. We recommend that:

- Contingency planning incorporate knowledgeable transporters into the process early to ensure the feasibility of courses of action. Transporters have tools and data systems to support rapid planning.
- Planning also consider how to redeploy forces rapidly and effectively if necessary.
- Planning factors be reexamined and better explained to users. Deploying units and personnel at enroute stage bases receive additional training.
- Expectations of optimal performance be lowered, for planning purposes, to be more realistic.
- Base operations receive continued attention. The United States needs to ensure access to adequate bases enroute and in the theater to support contingencies. Every unit and base should have transportation feasibility plans and a single identified point of contact for mobility operations. Planning should take into account increased communications capacity.
- The Air Force continue funding modernization of material-handling equipment. Other measures be taken to reduce congestion at pallet yards.
- The Defense Department strive to ensure that the U.S. Transportation Command or AMC has sufficient aircrews in a crisis. Consideration should be given to granting Commander, Air Mobility Command (COAMC) limited authority to call up airlift personnel in a transportation emergency, as can now be done with Stage I of the CRAF.
- Airlift modernization to replace the aging C-141 fleet take place. Modernization is essential to maintain the capability to mount an operation of this scale. The experience of Operation Desert Shield and Desert Storm also suggests that the existing fleet may

not be able to supply sufficient outsize cargo capability. The C-17 should be able to address both these problems, as well as provide greater throughput when airbase access is limited.

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The Command Analysis Group (XPY) at MAC was particularly helpful throughout our study. Colonel Jim Graham, Deputy Director of XPY when we visited MAC in October 1990, offered many insights and ideas. In the second stage of our study, Lieutenant Colonel Jay Marcotte generously extended the support of his staff. Colonel Craig Northrup, who succeeded Lieutenant Colonel Marcotte while an early draft was being revised, was as helpful as his predecessors. Lieutenant Colonel Al Jewell provided tremendous assistance in arranging our visits and finding the people and the data we needed, and patiently answering our many follow-up requests. Lieutenant Colonel Dave Merrill gave us an interesting briefing on the role of XPY during the war and helped us greatly on airlift modeling issues. Captain Mark Bracich provided an important database on aircraft use and percentage of aircraft available. Master Sergeant Matheson assisted us with the Military Airlift Integrated Reporting System

(MAIRS) database, and Lieutenant John Walker worked with us to validate results obtained from MAIRS. Major Jon Reynolds provided data on C-141 payloads during major exercises prior to the Persian Gulf war.

Much information was obtained elsewhere within the MAC command. Major Walter Mitchell of XPX performed a critical service by sourcing the directives in which C-141 payloads were restricted. Senior Master Sergeant Jack Odle of LGQA and Mr. Ken Fish of the same office helped us reconcile data on mission capable rates. Master Sergeant Mark Bauman (DOOMS) answered questions on the requirements cell. Historians Dr. Jay Smith and Dr. John Leland (HO) provided useful material.

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Lieutenant Colonel Tom McConnell, from ASC/SDCA, found data on the KC-135s' contribution to the airlift effort.

Numerous RAND colleagues made substantial contributions. Paul Killingsworth coauthored the airlift portion of the Project AIR FORCE study of the Phase I deployments in Desert Shield, and much of the analysis and data in this study results directly from his efforts. Fred Frostic led that study and has made many insightful comments along the way. Natalie Crawford, director of Project AIR FORCE's Theater Force Employment Program, provided generous support and made essential contacts for us at MAC. David Oaks helped with early data entry and analysis. Chris Bowie, David Kassing, and Mort Berman offered useful comments on the work as it progressed. Jerry Sollinger assisted greatly in the rewrite. Lieutenant Colonel David Randle and Lieutenant Colonel David Todd, resident Air Force Fellows at the time the draft was being revised, were enormously helpful in tying

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Any errors of fact or interpretation are the sole responsibility of the authors.

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ACL	Allowable Cabin Load
Air Reserve	The reserve component of the Air Force, including both Reserve Associate and Unit Equipped units
ALCC	Airlift Control Center
ALCE	Airlift Control Element
AMC	Air Mobility Command
AOR	Area of Responsibility
APOD	Aerial Port of Debarkation (offload)
APOE	Aerial Port of Embarkation (onload)
ARC	Air Reserve Component
ARCENT	Army Component Commanders, Central Command
CAT	Crisis Action Team
C-Day	The day on which the deployment begins
CENTAF	Central Command Air Forces
CENTCOM	Central Command
Channel	APOE/APOD pairs between which airlift service may be provided on a routine, scheduled basis
CINCMAC	Commander in Chief, Military Airlift Command
COAMC	Commander, Air Mobility Command
COMALF	Commander, Airlift Forces
CONOPS	Concept of Operations
CONUS	Continental United States
COSCOM	Corps Support Commander
CRAF	Civil Reserve Air Fleet
D-Day	The day on which operations/hostilities begin
DRB	Division Ready Brigade
JCS	Joint Chiefs of Staff
JFACC	Joint Forces Air Component Commander

JOPES	Joint Operations Planning and Execution System
MAC	Military Airlift Command
MAGTF	Marine Air-Ground Task Force
MAIRS	Military Airlift Integrated Reporting System
MHE	Material-handling equipment
Mission	Typically (although not always) a round-trip flight involving many sorties
MOG	Maximum (aircraft) on ground
MRC	Major Regional Contingency
ODS	Operation Desert Shield/Storm
PAA	Primary Authorized Aircraft
PAX	Passengers
Reserve Associate	Reserve units that share assets assigned to active duty units on the same base
Sortie	A point-to-point flight with no intermediate stops
STons	Short tons
STRATFOR	Strategic Forces
TAI	Total aircraft (in) inventory
TPFDD	Time-Phased Force Deployment Data
TPFDL	Time-Phased Force Deployment List
TRANSCOM	Transportation Command
ULN	Unit Line Number; an alphanumeric identifier of a unit, or of equipment
Unit Equipped	Reserve units that are assigned their own assets, in particular, aircraft
USE rate	Average flying hours per aircraft per day. As opposed to the utilization (UTE) rate, the USE rate is computed only for those aircraft (usually mission-capable) applied to a specific mission. [AFP 76-2, p. 27]
UTE rate	(Utilization rate) Average flying hours per aircraft per day, produced by aggregating the hours flown by all aircraft and dividing by the total number of aircraft, whether or not they flew.

Chapter One

INTRODUCTION

On 7 August 1990, in response to the Iraqi invasion of Kuwait, President George Bush announced his decision to send United States military forces to aid in the defense of Saudi Arabia. Within hours, the first planeload of people departed for the kingdom. Thus began the largest airlift of combat forces in history. Over the course of the next seven months, the Air Force's Military Airlift Command (MAC)[1] would fly almost 15,000 strategic airlift missions using both military and civil aircraft, transporting over 500,000 tons of cargo and almost 500,000 passengers. In the months following the war, MAC would fly those people back home.

The nation has historically relied on a balance of capabilities when deploying forces to the site of a crisis. Prepositioned material, sealift, and airlift—frequently called the mobility triad—provide this balance. Each leg of the triad has different strengths and weaknesses. Prepositioning involves placing stocks near or in potential trouble spots. Although expensive and the least flexible of the three, prepositioning can provide an invaluable capability. Sealift can move enormous quantities almost anywhere, but it takes time to respond. Airlift offers flexibility equal to that of sealift, but it can respond rapidly, frequently in a matter of hours. Operations Desert Shield

[1]On 1 June 1992, the United States Air Force instituted a major reorganization of its command. Most of the responsibilities previously assumed by MAC were taken over by the Air Mobility Command (AMC). However, at the time of Operation Desert Shield, the command was still known as Military Airlift Command. This report will therefore refer to MAC.

and Desert Storm (ODS) provide a case study of the mobility triad. However, this report will focus only on the airlift portion.

This study presents Project AIR FORCE's analysis of the airlift to the Persian Gulf. We do not offer a history of the airlift operation. The contributions and accomplishments of the thousands of people who made this feat possible will not be recounted here. Nor do we offer comprehensive "lessons learned" from Desert Shield and Desert Storm. We have been deliberately selective.

Instead, this study offers an analysis of the strategic airlift operation, *focusing on issues of operational efficiency.* By comparing data from the airlift operation with expectations derived from planning factors, we attempt to explain the substantial differences. The report describes in broad terms how well the strategic airlift system performed, explains why the system did well or poorly in certain areas, and suggests the implications that these findings hold for the future. In particular, it seeks to discern patterns in the data that may not have been apparent to the participants while the deployment was happening, and that provide a better insight into implications for future operations. While making extensive use of quantitative data, this analysis also sought, where possible, to complement the data with interviews of participants. We want to explain the story behind the numbers to achieve a fuller insight into the lessons of the Desert Shield and Desert Storm airlift.

This analysis does not address tactical airlift operations, as critical as they were. Although we originally intended to assess these operations as well, adequate data simply were not available to permit us to do so.

Project AIR FORCE is addressing the contribution of the Civil Reserve Air Fleet (CRAF) to the Gulf airlift in a separate paper.[2] CRAF operations will be discussed here to the extent that they affected questions of operational efficiency.

For this analysis, we relied primarily on the following sources for our information:

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[2]Mary Chenoweth, *Project AIR FORCE Analysis of the Air War in the Gulf: The Civil Reserve Air Fleet in Operation Desert Shield/Desert Storm*, N-3610/10-AF, forthcoming.

- Interviews with the staff of Headquarters, Military Airlift Command. In late October 1990, the Project AIR FORCE team interviewed General H. T. Johnson, Commander in Chief of MAC; the directors and staff of the Crisis Action Team (CAT); the director of the Command Analysis Group (XPY); and the Command Historians (HO). In August and September 1991, we interviewed staff in the Command Analysis Group, Aerial Port Operations (XON), Contingency and Exercise Management (XOOX), Programming and Policy (XPP), and the Command Historians. In January 1992 and again in June 1992 (under the auspices of Air Mobility Command), we briefed and interviewed Major General John Nowak, Deputy Chief of Staff for Logistics and Engineering (MAC/LE). In July 1992, we briefed Lieutenant General Walter Kross, Vice Commander of AMC; Major General Robert Dempsey, Chief of Staff; and Major General Paul Landers, Deputy Chief of Staff, Operations and Transportation. In February 1992, we briefed General Ronald Fogleman, Commander of AMC, and Major General Phillip Ford, Deputy Chief of Staff, Plans and Programs. Staff functional experts from the following offices at MAC/AMC provided frequent assistance: Logistics Plans (LGX), Surgeon General (SG), Tanker Airlift Control Center (TACC), Resource Division (XOR), Combat Operations and Training Division (XOT), Air Reserve Forces Advisors (XPB), Strategy, Planning, and Doctrine (XPD), Programming (XPP), Operations Plans (XPX), Command Analysis Group (XPY), and Requirements (XR).
- Interviews at 21st Air Force and the 438th Military Airlift Wing at McGuire Air Force Base, New Jersey, in January 1991.[3]
- Interviews with the Air Staff: In August 1992, we briefed Lieutenant General Buster Glosson, Director of Plans and Programs (AF/XO) and Major General Larry Henry (AF/XOR), as well as action officers from the Program Element Managers (PEM), the Plans and Operations Mobility Forces Branch (XOFM), and the Plans and Operations Joint Matters Branch (XOXJ). Staff functional experts from Studies and Analysis (AF/SA), and Airlift

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[3]Interviews were conducted by Paul Killingsworth for an earlier Project AIR FORCE study.

and Rescue Force (AF/XOOTA) provided assistance earlier in the study.

- Data from the Military Airlift Integrated Reporting System (MAIRS) database.[4]
- From a related study for the Army, interviews with transport planners at XVIII Airborne Corps, Fort Bragg, in September 1990.
- Various datasets, reports, and logs provided by MAC.

We did not have the opportunity to interview many key participants. We visited neither the theater nor the enroute bases, although we spoke to people who had deployed there. We did not speak to personnel at the 22nd Air Force. Nonetheless, we believe that the sources provided to us gave us enough information to permit us to paint a fairly detailed portrait of the operation.

The remainder of this analysis is divided into five chapters. Chapter Two provides a brief overview of the ODS airlift and introduces the questions of operational efficiency that have been raised by various observers. Chapter Three presents our analysis of the factors that limited strategic airlift operations during ODS. Chapter Four offers some observations on the implications for the future. Chapter Five

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[4]To avoid false entries we performed the following consistency checks:

- Deleted sorties in all missions that had more than one aircraft type.
- Created, from the remainder, a table from which to generate sortie statistics and a table from which to generate mission statistics.
- From the sortie table:
  - deleted sorties whose departure station did not match the previous arrival station.
  - deleted sorties whose time on ground was less than zero or greater than two days.
- From the mission table:
  - deleted missions with greater than 20 sorties.
  - replaced the delay for sorties whose departure station did not match the previous arrival station with the average delay for that aircraft type and the indicated delay category.
  - replaced the delay for sorties whose time on ground was less than zero or greater than two days with the average delay for that aircraft type and the indicated delay category.

summarizes our conclusions. Appendix A contains a series of tables presenting commonly requested statistics on the ODS airlift. Figures in Appendix B present C-141 payload distributions by base.

Chapter Two

OVERVIEW OF OPERATIONS

The deployment that began on 7 August 1990 was just the beginning of a large, complex operation involving all aspects of the strategic deployment system.[1] Prepositioned stocks, both ashore and afloat, provided a massive, early supply of munitions and combat and support equipment. Sealift would ultimately move 85 percent of all the dry cargo going to the Persian Gulf, but it would be several weeks before the first ship arrived. Strategic airlift provided the means of moving critical assets rapidly, especially in the first weeks of Desert Shield and in the period leading up to and into the war. It carried virtually all of the people deployed to and from the Gulf. It also transported a higher-than-expected proportion of dry cargo (15 percent versus the expected 5 percent) and sustainment cargo (30 percent versus the expected 10 percent).[2]

The operation can be usefully divided into four periods:

- Phase I: 7 August–9 November 1990. Deploying and sustaining forces to defend Saudi Arabia and the Gulf Cooperation Council states.
- Phase II: 10 November 1990–16 January 1991. Deploying offensive forces capable of evicting Iraq from Kuwait and sustaining deployed forces.

[1]A basic description of the deployment can be found in the unclassified version of the Defense Department report, *Conduct of the Persian Gulf War: An Interim Report to Congress*, pp. 3-1 to 3-5.

[2]Attributed to General H. T. Johnson, "MAC Faces Widening Gap in Peacetime, Crisis Needs," *Aviation Week & Space Technology*, September 9, 1991, p. 49.

- Phase III: 17 January–28 February 1991. Supporting and sustaining wartime operations.
- Phase IV: March-August 1991. Redeploying forces, sustaining remaining in-place forces, and supporting humanitarian operations.

This chapter sets the stage for later discussions. It offers an overview of the airlift with descriptions of each phase. The descriptions are not meant to be comprehensive histories, but merely sketches upon which to build for later discussions. We then close with questions raised, by ourselves or by others, on how well the airlift system performed.

HISTORICAL SUMMARY

From the start of Operation Desert Shield until the end of the war, MAC flew just under 15,000 missions. Of these, 77 percent were flown by organic (military) MAC airlifters (C-5s and C-141s), 3 percent by Strategic Air Command KC-10s,[3] and the remainder by civil aircraft (both CRAF and volunteers).[4] Table 1 summarizes the missions flown by aircraft type and by month.[5] The level of effort

[3]The KC-10 is a combined tanker and airlifter, based on the civilian DC-10. At the time of ODS, the KC-10s were assigned to SAC.

[4]For the remainder of this report, we will use "CRAF" as a shorthand for both CRAF-activated aircraft and aircraft volunteered by carriers.

[5]Many data tables provided to us by MAC used 30-day periods to normalize comparisons between months. The "months" correspond to these periods:

August:	8/7/90–9/15/90
September:	9/6/90–10/5/90
October:	10/6/90–11/4/90
November:	11/5/90–12/4/90
December	12/5/90–1/3/91
January:	1/4/91–2/2/91
February:	2/3/91–3/4/91

Table 1

Missions Flown: August 1990–February 1991

Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
Organic								
C-5	397	510	437	416	570	680	552	3,562
C-141	967	998	682	710	1,399	1,639	1,457	7,852
KC-10	17	88	55	50	115	48	0	373
Organic subtotal	1,381	1,596	1,174	1,176	2,084	2,367	2,009	11,787
CRAF								
Narrow body: Cargo	60	86	45	91	154	289	346	1,071
Narrow body: PAX	3	9	8	9	11	40	47	127
Wide body: Cargo	21	93	51	71	112	200	279	827
Wide body: PAX	88	121	145	44	281	246	109	1,034
CRAF subtotal	172	309	249	215	558	775	781	3,059
Total	1,553	1,905	1,423	1,391	2,642	3,142	2,790	14,846

SOURCE: MAIRS.

NOTES: Totals are for 30-day periods. PAX = passenger.

varied significantly over time. In August and September, MAC surged to deploy the initial forces. In October and early November, the pace slackened slightly as the initial units finished deploying but picked up dramatically in December as the second set of deployments began and the United States prepared for war. Each period has its own story.

Pre-Crisis Preparations

The initial planning for a possible U.S. response to an Iraqi invasion of Kuwait had begun some months before the invasion, as part of the normal planning process. As Iraqi forces massed on the border of Kuwait in July 1990, planning efforts accelerated. Unfortunately, on 2 August 1990 the plan existed only as a "Concept Outline," and as such lacked a transportation plan.[6]

After the invasion on 2 August, planning became more intensive and specific courses of action were considered. This planning was "close-hold," and we have not had access to those involved in the process. To the best of our knowledge, based on numerous interviews with Air Force and Army planners, no experienced transport planners were involved in this process until the deployment order was issued on 7 August at 1700Z. Expectations of transportation capability appeared to have been based on older operational plans whose assumptions were invalid in this case. As a consequence, the initial requirements passed down by Central Command (CENTCOM) and Joint Chiefs of Staff (JCS) planners were infeasible.

On 2 August, MAC activated its Crisis Action Team. Although the CAT did not have any specific orders, it queried units about their status, estimated the available capacity under various assumptions, and developed its initial concepts of operations. Unfortunately, it could not plan a flow without explicit requirements, and none were being passed down from JCS or CENTCOM. MAC even closed the CAT on 6 August because it had nothing more to do. Yet several hours later MAC reactivated the CAT when informal notification was received from the MAC liaison officer at CENTCOM that the President was about to announce a major deployment. MAC put its primary num-

[6]*Conduct of the Persian Gulf War*, p. 3-1.

bered air forces—the 21st at McGuire and the 22nd at Travis—on alert.

Phase I: 7 August–6 November 1990

Early in any deployment, the airlift system tends to generate aircraft faster than deploying units can generate cargo; since airlift operations continue around the clock in peacetime, the initial shift for a contingency is relatively minor. This pattern held true in ODS. The first airlift sorties left with an advanced team from Central Command Air Forces (CENTAF) on 7 August. The first Division Ready Brigade (DRB) of the 82nd Airborne Division began to load onto airlifters in the early morning hours of 8 August. The F-15Cs of the 1st Tactical Fighter Wing along with some Airborne Warning and Control Systems (AWACS) began to move a few hours later. In the first few days, MAC sent airlift aircraft to these units as fast as they became available. Unfortunately, the units had trouble handling these initial high-flow rates, as will be discussed later.

As more units prepared to move and the requirements continued to grow, demand for airlift quickly outstripped available capacity. Although MAC had access to all its aircraft, airlift capacity was limited. Almost half of MAC's crews are in the reserves, which limits the length of time that MAC can continue at surge sortie rates. Although many reserve crews volunteered, there were not enough to continue operations for a sustained period. Also, to move large numbers of passengers, MAC usually plans to use civil aircraft such as the Boeing 747. Some civil aircraft were made available, but MAC needed a more complete and reliable solution. On 17 August (C+10), General H. T. Johnson, Commander in Chief of MAC (CINCMAC) and of the U.S. Transportation Command (CINCTRANSCOM), ordered the activation of the first stage of the Civil Reserve Air Fleet. CRAF Stage I added 17 passenger and 21 cargo aircraft. This event marked the first time since the inception of the program that CRAF had been activated. CINCMAC has the authority to declare a transportation emergency and to call up CRAF Stage I. Unfortunately, he does not have similar authority to activate MAC reservists; this authority rests with the President. Not until 23 August (C+16) did the President approve a limited call-up of reserves, allowing MAC to gain more crews.

Despite the problems encountered, MAC transported an impressive combat force to the Gulf in that first month. By 10 August (C+3), over 100 combat aircraft were in the theater; the first DRB of the 82nd Airborne deployed within a week. The first Maritime Prepositioning Ship for the Marines would arrive on 16 August (C+8), carrying equipment for a Marine Air-Ground Task Force (MAGTF); with MAC providing the airlift for the personnel, a moderately heavy ground force could be deployed in less than two weeks. By the time the first ships were arriving from the Continental United States (CONUS), MAC had deployed the equipment and personnel for a few hundred combat aircraft, an airborne division, personnel for the MAGTF, and elements of the 101st Airborne Division.[7] By 6 September (C+30), MAC had transported almost 50,000 short tons of cargo and over 70,000 passengers to the Gulf (see Tables 2 and 3 for the monthly totals of cargo and passengers, respectively).

By late September, most high-priority units and cargo had been deployed. As requirements slackened, MAC began to reduce the pace of its operations. It flew fewer missions and conducted much deferred maintenance. However, this proved to be merely the lull before the storm.

Phase II: 9 November 1990–16 January 1991

On 9 November, President Bush ordered the deployment of additional combat troops to the Gulf. Counting support personnel, this additional complement would ultimately grow to 250,000 troops beyond those deployed in Phase I. These forces would permit the United Nations coalition to take offensive actions to expel Iraqi forces from Kuwait.

For MAC, Phase II deployments were dominated by (a) passenger movement in support of the deployment of VII Corps stationed in Germany, a third armored division from CONUS, additional Marine troops, and various support units, and (b) a growing sustainment cargo requirement. The VII Corps would form the main armored attack force in the coalition. While its equipment would go primarily

[7] *Conduct of the Persian Gulf War*, pp. 3-1 to 3-2.

Table 2

Short Tons Transported

Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
Organic								
C-5	23,145	32,385	26,133	26,250	34,314	42,568	33,562	218,356
C-141	18,470	19,261	12,071	12,922	26,161	31,469	28,703	149,058
KC-10	546	3,450	1,848	1,660	3,439	1,344	0	12,286
Organic subtotal	42,161	55,096	40,052	40,832	63,914	75,381	62,265	379,700
CRAF								
Narrow body: Cargo	1,764	2,331	1,256	2,020	3,203	6,445	8,235	25,253
Narrow body: PAX	59	181	96	135	155	448	437	1,511
Wide body: Cargo	1,464	7,031	3,947	5,829	8,042	14,560	19,837	60,710
Wide body: PAX	4,523	5,381	5,423	1,901	14,612	11,783	5,287	49,410
CRAF subtotal	7,810	15,424	10,722	9,885	26,012	33,236	33,796	136,884
Total	49,971	70,519	50,774	50,717	89,926	108,617	96,060	516,582

SOURCE: MAC/XPY.

NOTE: Totals are for 30-day periods. PAX = passenger.

Table 3

Passengers Carried

Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
Organic								
C-5	20,207	13,362	5,943	5,034	12,768	16,320	7,231	80,865
C-141	18,566	8,184	3,342	4,828	19,166	28,683	5,828	88,597
KC-10	102	114	94	135	529	125	0	1,099
Organic subtotal	38,875	21,650	9,379	9,997	32,463	45,128	13,059	170,561
CRAF								
Narrow body: Cargo	6	0	0	18	92	434	208	758
Narrow body: PAX	415	1,143	353	624	728	2,672	2,712	8,647
Wide body: Cargo	27	37	0	0	0	20	28	112
Wide body: PAX	31,293	37,437	40,281	12,047	77,809	67,970	27,675	294,512
CRAF subtotal	31,741	38,617	40,634	12,689	76,629	71,096	30,623	304,029
Total	70,617	60,278	50,012	22,686	111,093	116,223	43,682	474,589

SOURCE: MAC/XPY.

NOTE: Totals are for 30-day periods.

by sea, its personnel would be flown to the Gulf. At the same time, the growing number of forces in the Gulf required ever greater amounts of sustainment cargo.

The movement of passengers posed the greatest challenge to MAC in this second phase. CENTCOM established a deadline of 15 January 1991 for the deployment of all combat troops. During the months of December and January, MAC carried over 225,000 passengers (see Table 3), for an average of 3750 per day. Clearly, the CRAF wide-body passenger aircraft dominated in this mission, carrying 62 percent of all the troops deployed to the Gulf. Yet, although civil aircraft carried most of the passengers, there was not enough capability with the civil aircraft at hand (CRAF Stage I and contracted aircraft) to meet the requirement. Therefore, MAC converted some C-141s to a passenger configuration in late December and January to meet the closure requirements. As indicated in Table 3, the number of passengers carried on C-141s increased substantially from November to December and January.

As the United States deployed more and more forces, sustaining those forces through channel operations[8] became increasingly important. As shown in Table 4, the number of channel missions grew rapidly, from 8 in August to 885 in November (or approximately 30 per day). By February, during the height of the war, this would increase to over 45 missions per day. In terms of tonnage, MAC moved 74 percent more channel cargo per day in February than in November.[9] The steady increase in sustainment cargo can be seen plainly in Figure 1. Overall, airlift moved 30 percent of all the sustainment cargo, substantially more than the 10 percent anticipated before the crisis.

[8]A channel operation is an established logistics route (between major installations) with some known expectation of cargo and passenger transportation requirements (or of frequency requirements) from a variety of users. A unit move is the movement, from one location to another, of a single organization. Airlift, in most cases, is dedicated to that unit's movement. There is no stardard route for a unit move.

[9]Although the number of missions increased by only 50 percent, the amount of cargo carried rose more because of the greater use of CRAF B-747s.

Table 4

Channel and Unit Deployment Missions

Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
Unit moves	1,545	1,640	871	506	1,544	2,020	1,429	9,555
Channel operations	8	265	552	885	1,098	1,122	1,361	5,291
Total	1,553	1,905	1,423	1,391	2,642	3,142	2,790	14,846
Channel as percent of total	1%	14%	39%	64%	42%	36%	49%	36%

SOURCE: MAC/XPY.

NOTES: Totals are for 30-day periods. Unit moves are those missions scheduled against Unit Line Numbers in the Time-Phased Force Deployment List (TPFDL).

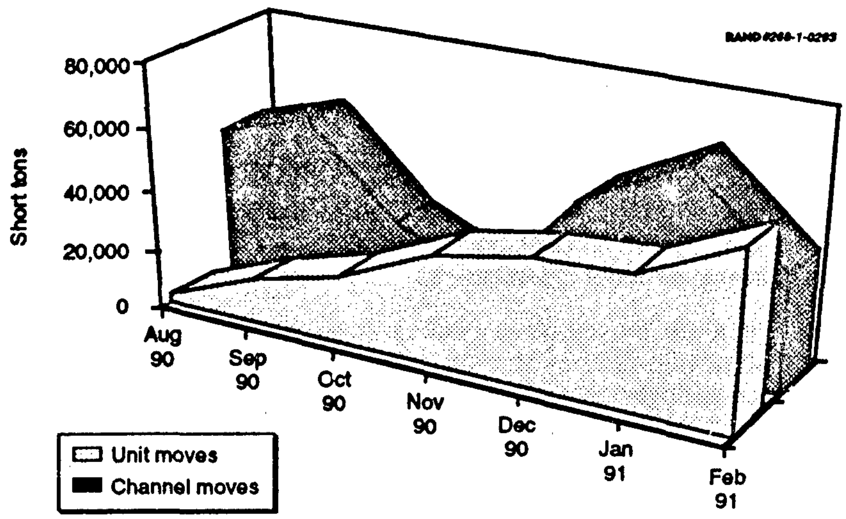

Figure 1—Sustainment and Unit Cargo Tonnage

Phase III: The War, 17 January–28 February 1991

In many ways, the start of the war did little to change MAC's operations; MAC had been effectively at war since 7 August. Nevertheless, the outbreak of hostilities did bring one new circumstance that seriously affected MAC operations—Scud attacks. The attacks by Iraqi Scud missiles on Saudi Arabian airfields and on Israeli cities led to two responses: first, many CRAF participants refused to fly into targeted areas at night, when the attacks came; and second, the President ordered the deployment of Patriot missile units to Israel.

The missile attacks on Dhahran and Riyadh had long been anticipated. The greatest concern was that the warheads would carry chemical weapons. The airlines were particularly troubled by this prospect. Without chemical gear for its crews and reliable intelligence on the threat, many airlines refused to fly into these bases at night. This refusal complicated mission planning for MAC, but under the circumstances it agreed to accommodate the airlines.

In response to the Scud attacks on Israel, President Bush ordered the deployment of Patriot batteries to that country. MAC and the Army

responded swiftly, and within 24 hours the first fire units were deployed.[10] MAC diverted most of its C-5s (the only aircraft that can handle the many pieces of outsize equipment in a Patriot battery) and many of its C-141s (to carry missiles and other equipment) from other missions to support this move. Within days the deployment was complete. This experience highlighted the inherent flexibility of airlift and the significant contribution it can make in a rapidly changing operational environment.

Strategic airlift moved other vital cargo to the Gulf during the war. For instance, in January the Army found that its armored units did not have enough heavy equipment transporters (HETs), assets that would be critical to moving these units in preparation for the ground war. Since at that point shipping the HETs by sea would take too long, CENTCOM decided to move them by air. Only the C-5 could move this outsize equipment. Coming at the same time as the Patriot move, this placed a heavy demand on the limited C-5 fleet. Later, the Air Force needed to move the new GBU-28 "bunker buster" guided bomb to the Gulf quickly and secretly; organic strategic airlift was the answer. Throughout the war, unexpected requirements for high-priority items meant that airlift was constantly in demand.

Phase IV: Redeployment and Postwar Activities, March–August 1991

For MAC, the war did not end with the cease-fire. First, sustainment missions had to continue to support the half-million troops in the theater and to replenish spent stocks if fighting resumed. Second, all the troops that deployed to the Gulf would need to be flown back home. The redeployment of troops would occur much faster than the deployment, eventually averaging over 5000 passengers per day. Third, the United States began offering humanitarian aid to various groups in Iraq under Operation Provide Comfort. These various demands kept MAC's operational tempo high for many months. Not

[10]This speedy reaction was aided by the fact that a Patriot unit was already preparing for deployment to the Gulf.

until the end of July 1991 did MAC complete the ODS missions. Forty-two days of combat required a year of airlift.

PERFORMANCE SHORTFALLS

Despite the many outstanding achievements of the ODS airlift, some people have criticized the airlift system for failing to deliver its full capability, or at least what they believed this capability to be. Unmet expectations could be seen in many ways. Initial requirements for airlift passed down by CENTCOM were as much as three times larger than the capability MAC said it could provide. In numerous interviews with deploying units that used airlift, the RAND team heard serious complaints: that airlift was unreliable, coming too late or not at all; that units had little warning about when aircraft would arrive or what type of aircraft would be provided; and that payloads for the C-141 were substantially lower than planning factors.

Attention has been drawn to the various areas where airlift performed below planning factors. Utilization rates[11] fell well below expectations. The C-5 averaged only 5.7 hours per day, versus the commonly cited values of 11 for surge operations and 9 hours for sustained operations; the C-141 averaged 7.0 hours, versus 12.5 hours and 10 hours.[12] The average monthly rates can be seen in Figure 2. On average, only 67 percent of the C-5s were available, and at times only 50 percent were available; the C-141 performed better with an average availability rate of 84 percent.

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[11]Utilization (UTE) rate is the flying time in a specific period expressed in hours per aircraft. It measures the productivity of the *entire* fleet, including aircraft not flown. One calculates UTE rate by aggregating the hours flown by all aircraft and dividing by all aircraft, whether or not they flew during that period. Thus, one counts non-mission-capable aircraft and mission-capable aircraft not flown.

[12]Aircraft that did fly in ODS missions attained USE rates (average flying hours per mission-capable aircraft per day) close to the expected UTE rate of 10.1 hours for the C-141 and 9.7 hours for the C-5. However, these figures are not comparable. The UTE rate captures the effect of non-used aircraft (non-mission-capable aircraft and mission-capable aircraft not flown). Unless the existing plans assumed a 100 percent mission-capable rate, one would need to achieve a USE rate *higher* than this to attain the desired UTE rate. For more information on how UTE rates are determined, see Captain Rick Gearing and Major Jim Hill, "UTE Rates Revisited," *Airlift*, Spring 1988, pp. 18-21.

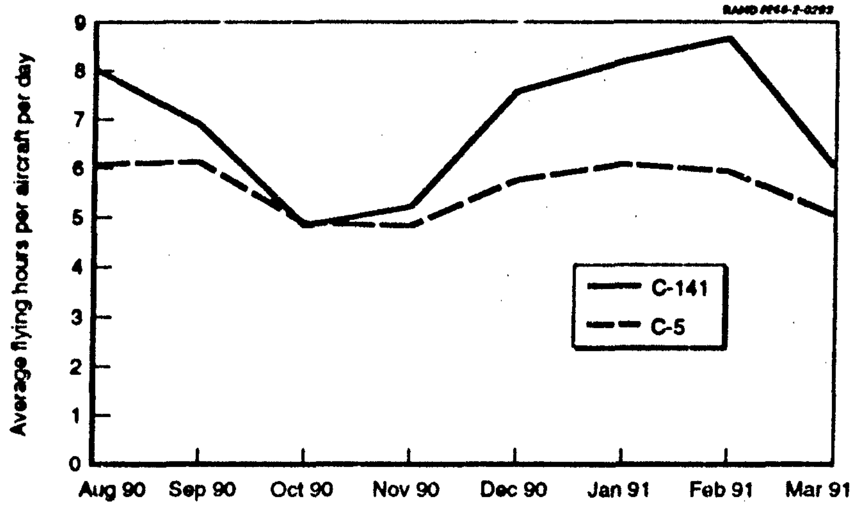

Figure 2—Utilization Rates for the C-5 and C-141 Fleets

Payloads were below published wartime planning factors.[13] As shown in Figure 3, payloads for the C-141 averaged only 74 percent of its wartime planning factor, and for narrow-body civil aircraft (DC-8s and B-707s) only 57 percent. In passenger missions, only the wide-body civil aircraft (B-747s, DC-10s, and L-1011s) came close to planning factors, as seen in Figure 4.

These figures have been checked by MAC and appear accurate, implying either serious inefficiencies in airlift operations, serious overestimation of capability in peacetime, a failure by people outside the deployment community to understand the planning factors, or some combination of these factors. The remainder of this report will seek to explain these shortfalls in performance. On the basis of our analysis, we believe that four problem areas account for almost all of the deficiencies:

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[13]See Department of the Air Force, Air Force Pamphlet 76-2, *Military Airlift: Airlift Planning Factors*, 29 May 1987.

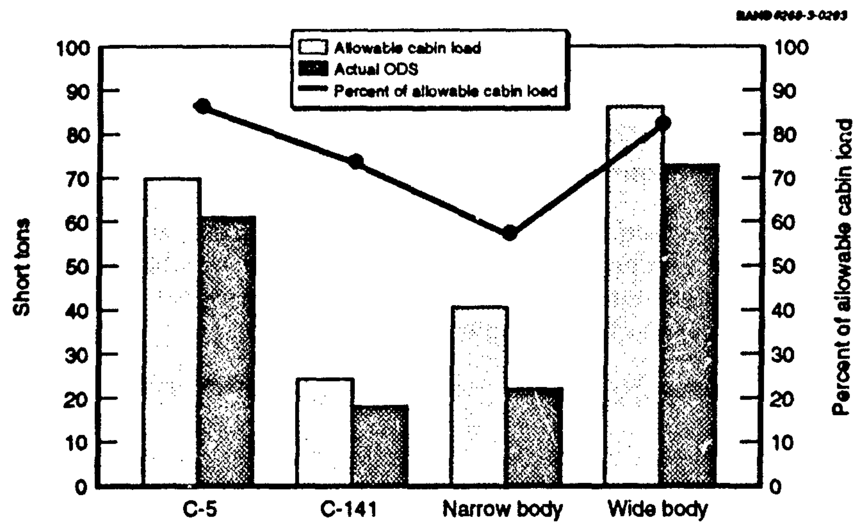

Figure 3—Payloads: Actual Versus Planning Factors

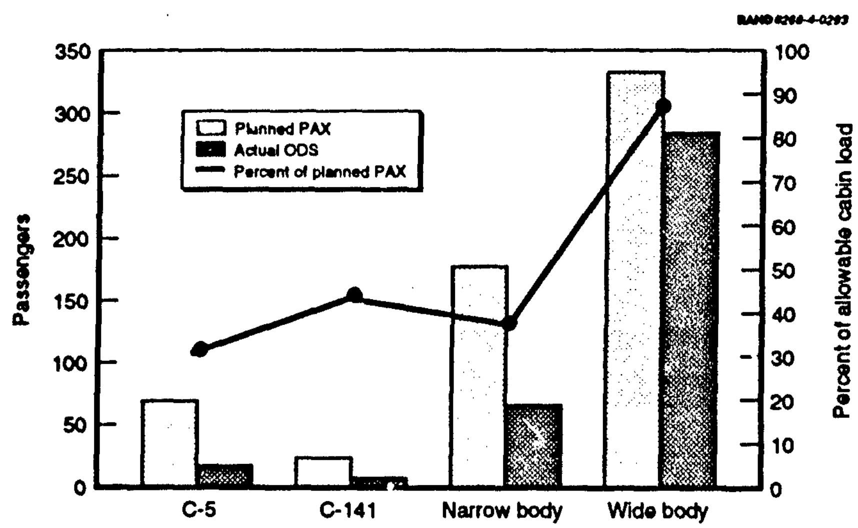

Figure 4—Passengers Carried: Actual Versus Planning Factors

- Planning
- Aircrew availability
- Bases
- Aircraft performance

Many of these factors were beyond the control of MAC, at least in the short run of the operation. Fortunately, most of the problems can be solved or ameliorated; the last chapter of this report will offer some recommendations toward this end.

Chapter Three

FACTORS THAT SUBSTANTIALLY LIMITED STRATEGIC AIRLIFT OPERATIONS

People often think of strategic airlift simply as a resource to be allocated. Yet airlift is also a system, consisting of many components that must work well together for the whole to function properly. To make efficient use of this limited resource, continual and careful planning is required to have aircraft where they are needed, when they are needed, and with as little idle time as possible. Prior to the aircraft's arrival at an onload base, a considerable amount of time and effort is needed to prepare the passengers and cargo for air shipment.[1] When the aircraft arrives, it must be unloaded, loaded, or both, by trained personnel with specialized equipment. Aircraft must be serviced and maintained, requiring adequate supplies and the right ground crews. Aircrews must be available in sufficient numbers to support the flow, and they must be rested and prepared for their missions.

In ODS, we found that problems existed in almost every component of the system, seriously constraining airlift operations. We have divided these problems into four broad categories: planning, aircrews,

[1]Passengers must be briefed and manifested prior to boarding the aircraft. Cargo must be marshaled and evaluated before loading. Hazardous materials must be identified and sorted so not to conflict with one another. Material must be placed on pallets, secured to the pallets by netting or straps, then weighed. Rolling stock (vehicles) must be prepared for air shipment—flammable fluids must be drained and purged. All cargo must be weighed (both pallets and rolling stock) and with this information a load plan must be developed. The load plan is the sequence in which the aircraft is loaded, accounting for center of gravity and floor load constraints. Prior to loading, this load plan must be approved by the aircraft's loadmaster.

bases, and aircraft performance. This chapter addresses each of these areas in turn.

PLANNING

Commonly cited planning factors for strategic airlift assume assets are used efficiently. Existing operational plans (OPLANS) with detailed transportation studies strive for optimal lift use and allocation. For instance, each OPLAN will have an extremely detailed database called a Time-Phased Force Deployment Data (TPFDD) with accurate and validated transportation information for every unit set to deploy. This TPFDD feeds into a Time-Phased Force Deployment List (TPFDL) that sets forth the sequence and timing for each unit move linked with specific airlift or sealift allocation. The entire plan is deconflicted and optimized to achieve the fastest possible closure of forces. Such efficiency requires extensive planning, usually taking 12 to 18 months. The nature of the ODS deployments precluded this.

Changing Requirements and Priorities

Operation Desert Shield began without a formal plan or TPFDD. The first units deployed simply based on gross estimates of lift requirements. The automated deployment system (the Joint Operations Planning and Execution System or JOPES) could not keep up with the rapid pace of change. As a result, in the initial weeks of ODS, all deployment planning and mission scheduling were done manually.[2,3]

The constantly changing requirements and priorities for deployments enormously complicated airlift planning. Since units began deploying with only a general sense of the total requirement, they frequently had to update their estimates during deployment. Units might request more lift than had been authorized by CENTCOM.

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[2]*Conduct of the Persian Gulf War*, p. 3-1. JOPES was a relatively new system, still in the early stages of development. It had not yet been fully instituted and not many people had been trained in it. Full development is not expected until the mid-1990s.

[3]In mid-August MAC had to stand-down the fleet for 12 hours, just to find out where all the airlifters were and where they were heading. At this point MAC established slot times in the theater and enforced a metered flow, so that aircraft would not arrive in theater before parking spots became available.

Without a TPFDD for this deployment, units used what data they had. Often, the databases proved to be out of date. Equipment phased out years earlier still appeared on the unit's equipment listing, while some newer pieces did not. At times, MAC was scheduled to move units that no longer existed. Another source of "changing" requirements was unauthorized changes to the TPFDD made by users of the JOPES. Anyone with a Worldwide Military Command and Control System (WWMCCS) terminal and an access code could alter the TPFDD. The system did not have adequate procedures to avoid unauthorized or inadvertent changes to the database. So even if the correct information had been entered, it could be changed later.

On the basis of the evolving situation in the theater, CENTCOM would reassess its priorities and reallocate lift. At times, priorities would be changed mid-mission. Airlift had the flexibility to adjust rapidly to these evolving requirements, but the result was to significantly reduce the airlift throughput in the longer run.

Ideally, the MAC CAT would have had the system primed for each move. It would ensure that the appropriate personnel and material-handling equipment (MHE) existed at a base before beginning a deployment; if not, they would schedule a prior mission with an Airlift Control Element (ALCE) and whatever MHE was needed, with enough time to assemble the equipment and set up operations. Diplomatic clearance, if needed, would be obtained. The CAT would ensure that a properly configured aircraft was available and that crews—air refueling qualified or airdrop qualified, as necessary[4]—were available to pick up the mission each step of the way. A crew flying from CONUS to Europe one day with a particular mission would go into crew rest in Europe, then would be scheduled to pick up another mission the next day. The CAT would do this for each mission and would ensure that the missions did not conflict with one another or with other operations.

Constant and unpredictable changes would upset this detailed planning. The effect would then ripple through the entire system. A change would not only affect those missions directly rescheduled,

[4]In fact, only one seven-ship formation of C-141s, from Torrejon, performed an airdrop.

but could disrupt many others as well. A mission enroute might be delayed because the crew that was to pick it up was diverted to a new, higher-priority mission. MHE and ALCE might be malpositioned. Airlifters might sit on alert waiting for a high-priority move, while other units, already prepared, sat without airlift. Automated systems could not respond quickly enough to meet real-time deadlines. For a variety of reasons, the data in these systems were often unreliable in any event. Thus, rescheduling had to be done manually, at least in the first few months.

The airlift of Patriots to Israel is a good example of how changing priorities affected the system. The rapid deployment was a great success, showing how strategic airlift could move high-priority units quickly, and proving that the advantage of airlift is flexibility. However, this success came at some cost. For several days, most C-5s and C-141s in the system were drawn off to meet this requirement, and the airlift system had difficulty adjusting to the change. Since some Patriot units from Ramstein were being moved, many airlifters simply flew back and forth from Germany to Israel. Crews and aircraft were mismatched. Crews coming off crew rest in CONUS might not have an aircraft to fly since few were returning from Europe. Crews flying in Europe were burning up crew hours. MAC was unable to rejuggle its assets (aircraft and aircrews) to continue working at peak performance. One MAC flow planner estimated that the deployment to Israel probably reduced the capacity of the airlift system by 10 percent for a week. Although we cannot confirm this figure, it seems quite reasonable.

The absence of a detailed plan also meant that at times airlift was significantly underutilized. For instance, in December when the large passenger movements from Europe dominated, MAC operations were severely hampered by the lack of a steady daily requirement. One day there might be a requirement to move 5000 troops to the Gulf; the next day none might be scheduled. Such surges and stops created enormous inefficiencies. Airfields were saturated one day and empty the next. Aircraft and aircrews would be out of place to ensure a continuous flow throughout the system. MAC was able to "smooth flow" many of the deployments but not all. Of course, one must expect these situations to arise in real-world operations, but it meant that MAC could not achieve the optimal level of performance set forth in normal OPLANS or planning factors. Since planning

factors are used by commanders to determine closure rates, which will affect the pace of the battle, it is a disservice to have the factors based on the assumption that everything will perform optimally.[5]

Unrealistic Planning Factors and Planning Assumptions

Planning factors—of utilization rates, mission-capable rates, and payloads—were unrealistic. Utilization rates were low for a host of reasons, as discussed in this report. Actual mission-capable rates fell short of advertised numbers, especially for the C-5 aircraft, which had not been fully exercised before Operation Desert Shield/Desert Storm. Payload planning factors were obsolete; for instance, MAC knew that there was a problem with the wing joint of the C-141 before Desert Shield, but did not revise the planning factors accordingly.

Planning assumptions were also overly optimistic. Planners did not worry, for instance, that offload bases would be a constraining factor; in other OPLANs there are ample in-theater bases, and Saudi Arabia is especially rich in infrastructure. In fact, offload bases were a bottleneck in the system, leaving one to wonder whether the problem is that it is difficult to prepare an OPLAN for every conceivable scenario, or that deliberate plans are of limited value because their assumptions are unrealizable.

Lack of Success in Harnessing Aerial Refueling Capabilities

Because there were not enough offload points in the theater, and because no stage base was provided for airlift crews, Brigadier General Patrick Caruana, Strategic Forces Commander (CENTAF/STRATFOR), tried to arrange for enroute refueling of strategic airlift sorties. This would serve two purposes—it would reduce the time the airlifters spent on the ground (enabling more of them to cycle through a given base in a given amount of time), and it would have allowed crews to more quickly return to staging bases in Europe. He was unsuccessful, for several reasons:

[5]Additionally, OPLANS do not capture the fact that some aircraft have other uses, including support missions unrelated to the contingency, training, and alert status. Those other missions do not obtain the high UTE rates expected in the OPLANS.

- Changing airlifter schedules
- Inadequate communication links
- Not all of the crews were air refueling (AR) qualified.

Changing airlifter schedules were especially difficult to accommodate in lieu of other tanker obligations. Inadequate communication links made it difficult to transmit information about changing schedules and allow for replanning. Command and control of incoming aircraft was very poor.[6] Sorties scheduled for aerial refueling often had crews that were not air refueling qualified—not all crews are air refueling qualified and there is no automated system to track the individual crew members and their attributes.[7] These problems, coupled with the fact that tankers were in high demand anyway, led STRATFOR to abandon the aerial refueling idea.

Had there been a more transparent airlift schedule and better coordination betwen MAC controlling agencies and STRATFOR, aerial refueling could have contributed to a more efficient Desert Shield/ Desert Storm operation.[8]

Planning for CRAF During the War

Prior to the outbreak of hostilities, many people inside and outside MAC were concerned about the risk posed to civilian aircraft in the event of attacks—especially chemical—on Saudi Arabian airfields. The carriers had expressed their concerns in a letter sent directly to the Chairman of the Joint Chiefs of Staff in late October. MAC had plans for modifying CRAF operations when the fighting started. On 13 January, MAC conducted a command post exercise to test procedures for diverting commercial aircraft. The basic concept was to stop the flow, divert aircraft to specified airfields, assess the situation, and restart the flow once things were in order.

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[6]The Airlift Control Center (ALCC) could not talk to an incoming aircraft until it was over the Red Sea; prior to that point, the ALCC personnel could not identify the geographical coordinates of an aircraft (Dr. Gary Leiser, "Oral History with Brigadier General Edwin Tenoso," 28 May 1991).

[7]MAC representatives argue that AR-qualified crews were formed and the STRATFOR commander was instructed accordingly.

[8]Brigadier General Patrick Caruana, private correspondence to the authors, June 1992.

Despite the preparations, the Scud attacks were far more disruptive than had been foreseen. Once the first missiles were fired, many aircraft diverted on their own to other fields or returned to Europe. Several carriers refused to permit their aircraft to fly to Dhahran. As the attacks continued over the following days, several major carriers refused to permit flights into the Area of Responsibility (AOR) at night, since the Scuds came then. Rather than make a major issue out of it, the MAC CAT decided to accommodate the carriers.

This move was not without costs. CRAF operations were already restricted to certain bases in the theater because of the proximity of several fields—like King Khalid Military City—to Iraqi forces. Restrictions at German airfields[9] further complicated flow planning, making it difficult to match slot times in Europe to slot times in the theater. Fortunately, MAC seems to have kept the net effect minimal, but if the Iraqis had used chemicals, the CRAF operations could have been profoundly disrupted.

Inadequate Redeployment Planning

Surprisingly, CENTCOM had not drafted a redeployment plan before the end of the war. People seemed to expect MAC and TRANSCOM to be able to work off the TPFDL in reverse. Even if this had been technically possible (it was not), it did not make operational sense: the order in which units were deployed was not necessarily the most sensible order for pulling them out; the aerial port of debarkation (APOD) for deployment (usually Dhahran) was often not the most expedient for redeployment, since most units had moved within the theater; equipment that had been airlifted over might well be sent back by ship; and equipment that had been damaged or destroyed might be left in theater.

MAC started to express the need for a redeployment plan during Phase II. It had sent a representative to the Pentagon and then to CENTCOM to propose that CENTCOM establish a redeployment office. However, an office was never established, and the result was utter chaos. Deployed units were scattered and mixed in the field. Communication with units was more difficult than during the de-

[9]See discussion of bases later in this chapter.

ployment, when they were at their home bases. Access to JOPES terminals and experienced personnel was rare for most deployed units. Mobility planners were largely in CONUS. Points of contact that had been identified by the MAC CAT in the theater returned to CONUS without passing on their duties or letting the CAT know who had assumed those duties. A number of units released their personnel with instructions to make their way home as best they could. They expected to find Space Available (Space-A) seating.[10] However, with the war over and everyone returning home, Space-A seats were not available. One Air Force officer recalled a situation in which thousands of men and women camped on an airfield among heavy and dangerous equipment, with no housing, mess, or sanitary facilities. In many ways, the redeployment was tougher than the deployment. Eventually a system was established and order restored but only after several weeks of confusion.

AIRCREW AVAILABILITY

Aircrews form an essential component of the airlift system that is all too often forgotten when people perform simple calculations of airlift capability. The standard, published utilization rates for airlift aircraft make two major assumptions concerning aircrews: (1) that all aircrews, both active and reserve components, are available for MAC's use, and (2) that stage facilities will be available where needed for optimal performance. In ODS, both of these assumptions proved false.

Late Call-Up of Reserves

MAC depends heavily on its reserve component. About half of the C-141 crews and 60 percent of the C-5 crews are in the reserves, along with significant numbers of personnel for aerial port squadrons, maintenance, and so forth. To gain the full utilization of its assets for sustained operations, MAC needs those crews; the oft-cited utilization rates for the C-5 and C-141 assume that these personnel have been activated. In ODS, the President did not authorize

[10]Space-A seating is a system whereby unused seats on MAC aircraft can be assigned to people without specific orders for that mission.

a reserve activation until 23 August (C+16). The first units were activated on 25 August, the last on 19 February (C+196). At that point, all C-5 air reserve component (ARC) units had been called and three-quarters of the C-141 ARC units. Table 5 shows these activations.

The less-than-complete call-up of C-141 units meant that MAC never had the crews necessary to achieve the full utilization rates. The C-5s were considered a more critical asset since only they could carry outsize cargo, and they generally provided more cargo capacity than the C-141s. With the movement of the 101st Airborne Division in late August and early September, this outsize capability was especially needed.

Lack of a Stage Base

Exacerbating the aircrew shortage was the lack of a "stage base." To understand the problem, one must first understand the concept of

Table 5

Activation of MAC Reserve Component Military Airlift Squadrons

Date	C-5 Unit	Type[a]	C-141 Unit	Type
25 August 1990	137 MAS	ANG ✈	183 MAS	ANG ✈
(C+18)	337 MAS	AR ✈	732 MAS	Reserve Assoc.
			756 MAS	AR ✈
31 August 1990	68 MAS	AR ✈		
(C+24)	301 MAS	Reserve Assoc.		
	326 MAS	Reserve Assoc.		
4 September 1990	312 MAS	Reserve Assoc.		
(C+28)	709 MAS	Reserve Assoc.		
9 September 1990			335 MAS	Reserve Assoc.
(C+33)			701 MAS	Reserve Assoc.
10 September 1990			708 MAS	Reserve Assoc.
(C+34)			97 MAS	Reserve Assoc.
24 January 1991			300 MAS	Reserve Assoc.
(C+170)			729 MAS	Reserve Assoc.
19 February 1991	702 MAS	Reserve Assoc.		
(C+196)	730 MAS	Reserve Assoc.		

SOURCE: MAC Command Historian (MAC/HO).

[a]MAS = Military Airlift Squadron, AR = Air Reserve, ANG = Air National Guard, and ✈ = Unit Equipped.

crew duty days and flying-hour management. For safety reasons, the Air Force limits airlift aircrews in normal operations to 16 hours per day, 125 hours each 30-day period, and 330 hours each 90-day period. Early in August, MAC raised these limits to 18, 150, and 400 hours, respectively. The Command Surgeon, after considerable study and monitoring of crew members, determined that further easing of limits could not be permitted. Given that a typical sortie from Europe to the theater might take seven hours flying time, plus three hours for pre-mission planning and post-mission activities, a typical sortie would use up around ten hours of crew duty time. From CONUS to Europe, the mission might last 12–15 hours, including pre- and post-mission activities. Even with delays or additional mission legs (for refueling or repositioning in-theater), crews would have been well within the 18-hour daily limits, and, theoretically at least, could have flown missions every day or two and remained within the 150-hour, 30-day limit. The challenge for MAC planners is to manage the available crews and their remaining hours to gain the most capability possible. Wisely managing crews becomes even more critical when the full crew complement is not available.

MAC's original concept of operations for ODS was to have a crew pick up an aircraft in CONUS, fly to an onload base, then continue to an enroute base (usually in Europe). There, the crew would go into crew rest; a fresh crew would pick up the plane, which would have been refueled, and continue the mission to the theater. The cargo or passengers would be offloaded, the crew would fly the aircraft to a theater stage base, and go into crew rest. A third crew would pick up the aircraft and continue the journey back to Europe, where a fourth crew would take the aircraft back to CONUS. Each crew would use up 10 to 15 hours of its monthly duty limit while remaining within the daily limit of 18 hours.

Unfortunately, CENTCOM denied MAC a stage base in the theater, thus precluding the possibility of crew rest. This situation meant that the crew flying from Europe would have to bring the aircraft back, resulting in a 20–24-hour crew duty day. MAC was forced to use augmented crews. Specifically, MAC used three rather than two pilots per aircraft flying from Europe to the theater and back. With an augmented crew, the crew duty day increases to 24 hours per day. However, the monthly and quarterly limits do not change. So whereas the use of augmented crews permitted operations to con-

tinue, it used up crew flying hours at a much higher rate. *Given limited availability of crews, the lack of a stage base would result in a 20 to 25 percent reduction in strategic airlift capability.* Initially, this effect would probably not show up in daily capability, as MAC would push to get the most capability out of the system, hoping to get a call-up of reserve crews. Instead, the problem would manifest itself as a dramatic decline after about three weeks as crews used up their monthly limit.[11]

Exactly this phenomenon occurred in ODS. At the start of the operation, MAC had only active crews, reserve crews who were doing their normal duty, and some volunteers. In mid-August, MAC analysts (MAC/XPY) calculated that without a call-up of additional crews, MAC would run out of crew hours for the C-5 fleet by C+19 (26 August) and for the C-141 fleet by C+21 (28 August). The call-up of

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[11]This situation can be illustrated with a simplified example. Let us say that a typical mission consists of a 15-hour leg from CONUS to Europe, a 10-hour leg from Europe to the theater, and then the same legs returning. With a crew stage base in theater, each mission would use up 100 hours from the pilot pool:

$$(15 \text{ hours} \times 2 \text{ pilots}) + (10 \times 2) + (10 \times 2) + (15 \times 2) = 100 \text{ pilot hours}$$

Without a stage bas[illegible]ng three pilots for the Europe-theater-Europe leg, we get:

$$(15 \text{ hours} \times 2 \text{ pilots}) + (20 \times 3) + (15 \times 2) = 120 \text{ pilot hours}$$

Thus, the lack of a stage base increases by 20 percent the number of hours used per mission

To see how this might affect the whole fleet, let's assume that MAC has 400 pilots, each of whom can fly 150 hours a month. If each mission uses 100 pilot hours, 600 missions per month can be supported:

$$\frac{400 \text{ pilots} \times 150 \text{ hours/month}}{100 \text{ pilot hours/mission}} = \frac{60,000 \text{ pilot hours/month}}{100 \text{ pilot hours/mission}}$$
$$= 600 \text{ missions/month}$$

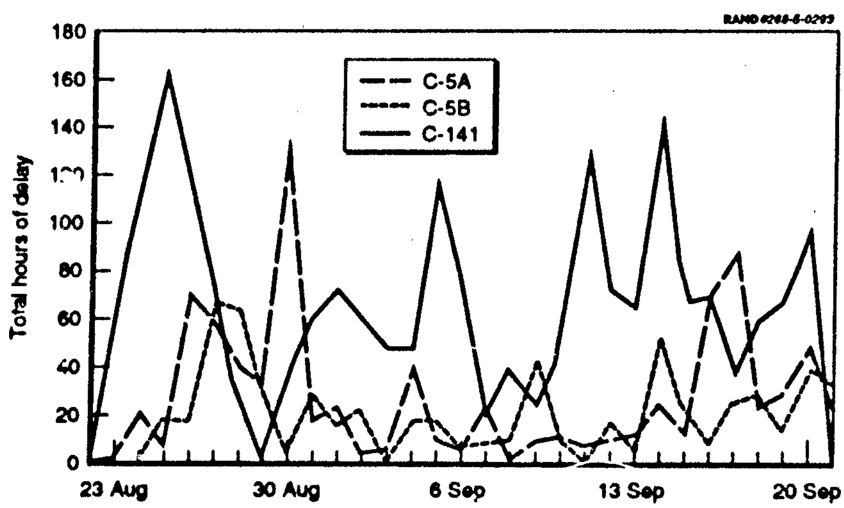
However, if augmented crews were required, then only 500 missions could be flown per month:

$$\frac{(400 \text{ pilots} \times 150 \text{ hours/month})}{120 \text{ pilot hours/mission}} = \frac{60,000 \text{ pilot hours/month}}{120 \text{ pilot hours/mission}}$$
$$= 500 \text{ missions/month}$$

Finally, let us say that MAC has 75 mission-capable aircraft available every day, and that a round-trip cycle takes three days. Therefore, there would be enough aircraft to support 25 missions per day. With a stage base, MAC could continue flying for 24 days without running out of pilot hours; without a stage base, it would run out on day 20.

the reserves on C+16 (23 August) came just in time to avoid a complete breakdown of the system. Even so, in the following days the mission delays resulting from crew rest requirements grew significantly for both the C-141 and C-5 fleets, as shown in Figure 5.[12]

We have not been able to uncover the definitive reason why CENTCOM did not establish a stage base for MAC in the theater. An interview with a senior CENTCOM officer suggests that the command was concerned about housing several hundred more personnel around already saturated airbases. He also indicated that, for the "minor" reduction in capability, CENTCOM decided not to pursue the issue given all the other more pressing matters before it. As we have seen, however, the reduction in capability was potentially large



SOURCE: MAIRS

Figure 5—Delays Resulting from Crew Rest Requirements

[12]In consultation with AMC, we have developed a new method for calculating delays that is used in this report. We calculate the time on ground (actual arrival time versus actual departure time) and subtract the planning factors' expected time on ground. The resultant "delays" are credited to whatever category is identified as being the primary cause of delays. (The delay times entered in conjunction with the delay causes are incomplete and error-prone.)

and could have had a substantial impact on the amount of combat force delivered to the Gulf if Saddam Hussein had decided to move into Saudi Arabia in August or September.

ONLOAD, OFFLOAD, AND ENROUTE BASES

The next problem area can be found in the bases or airports where people and equipment embark ("Aerial Ports of Embarkation" or APOEs), disembark ("Aerial Ports of Debarkation" or APODs), and the enroute bases where aircraft stop to refuel and change crews.

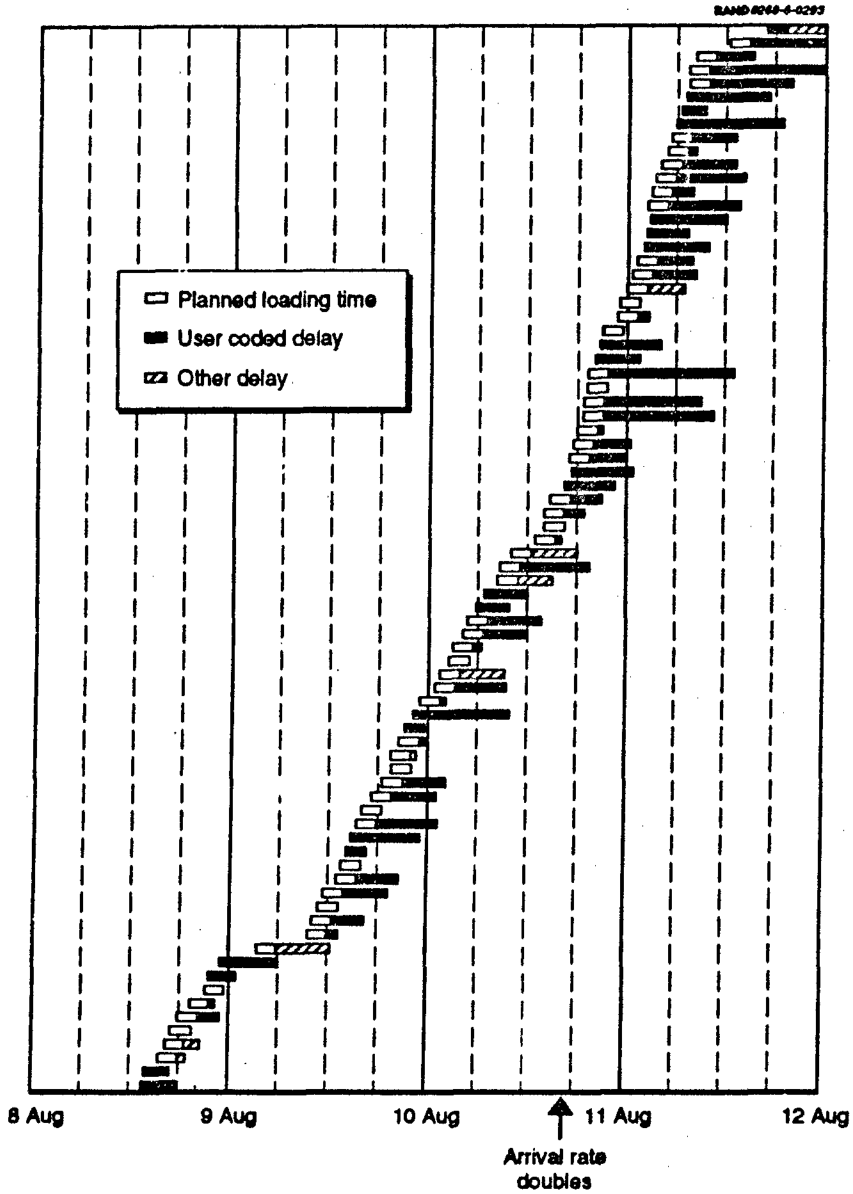
Early Deployments Hampered by Slow Cargo Generation

The first major units to deploy were the 1st Tactical Fighter Wing from Langley Air Force Base and the first Division Ready Brigade (DRB 1) of the 82nd Airborne Division at Ft. Bragg/Pope Air Force Base. These units represent the elite, cutting edge of U.S. contingency forces. Their experience came to illustrate the enormous problems in rapid deployment faced by even the best units.

The first combat unit to begin deploying was DRB 1 of the 82nd Airborne Division. The first aircraft with unit equipment and personnel left on the afternoon of 8 August. The airflow began with fits and starts while the unit prepared and CENTCOM decided the allocation of airlift to the unit. This allocation would change repeatedly in the first week of the deployment. Initially, MAC planned to flow one airlifter an hour into Pope Air Force Base to move DRB 1. However, sometime on 9 August or early 10 August, the decision was made to flow two airlifters an hour into Pope to support the 82nd Airborne. At 1700 hours (local time), this arrival rate commenced. In the next few hours, the Army had increasing trouble generating cargo fast enough to keep up with the arriving aircraft, and aircraft began to back up on the ramp.

Figure 6 illustrates this problem graphically. Each horizontal bar represents one airlift aircraft (C-5, C-141, B-747, etc.). The white portion of the bar indicates the planned loading time.[13] If the air-

[13] Times in these charts, taken from MAIRS, are in Greenwich Mean Time.



SOURCE: MAIRS

Figure 6—82nd Airborne Airlift Missions: 8–11 August 1990

craft were delayed because of "user coded" delay[14]—delays attributed to DRB 1 of the 82nd in this case—the delay is shown in black. Other delays (logistics, air traffic control, weather, etc.) are shown in stripes. The dasned vertical lines indicate six-hour periods.

By the morning of 11 August, the situation at Pope had become unsustainable. At 0600 hours, 16 aircraft were sitting on the ramp, 12 of which were delayed because of the unit's inability to generate cargo quickly enough. MAC began to divert aircraft to other fields to avoid additional congestion.[15] MAC also called a halt to the half-hourly arrivals. After stopping the flow for about 12 hours, MAC resumed flying missions into Pope, but at the rate of one every hour. Operations improved immediately and dramatically, as shown in Figure 7. Delays became infrequent; when they did occur, they were less severe.

The 1st Tactical Fighter Wing (TFW) at Langley Air Force Base, equipped with F-15Cs, faced similar problems. MAC provided as many airlifters as possible to deploy the unit. In the first six hours, nine C-141s and three C-5s arrived, or an average of two airlifters an hour. Problems quickly arose in the airlift flow. Of the first 16 airlifters, 11 had delays attributed to the deploying unit. The average "user coded" delay for those first 16 missions was 6.25 hours. Figure 8 illustrates this problem. As can be seen, the delays started with the first mission and continued for the next day and a half.

In scheduling the next set of missions for Langley, MAC and Tactical Air Command (TAC) decided to reduce the flow rate to about one per hour (in reality, it worked out to one every 1.3 hours). This action dramatically improved the performance. The average delay attributable to the user for the next 22 missions was 9 minutes.

On the basis of the early experience at Langley and Pope, MAC decided it would normally schedule no more than one aircraft an hour into an onload base. The 82nd Airborne Division and the 1st Tactical

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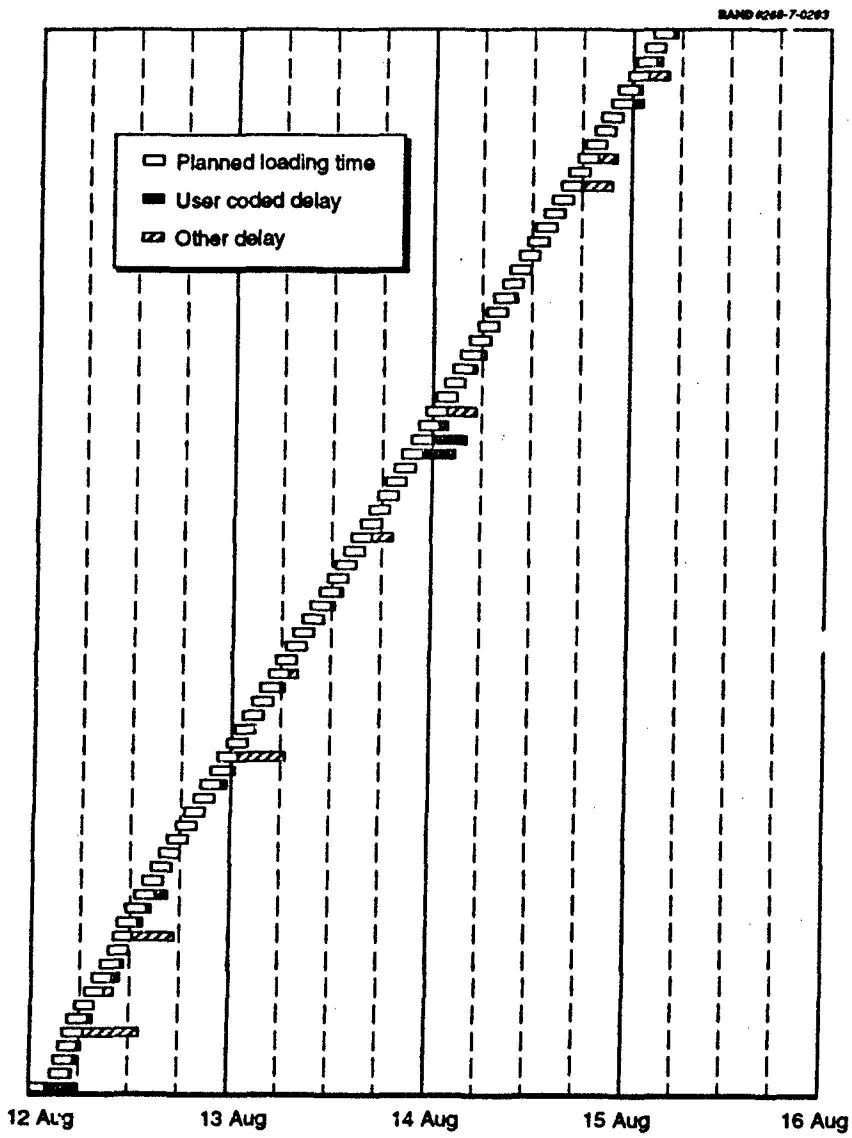
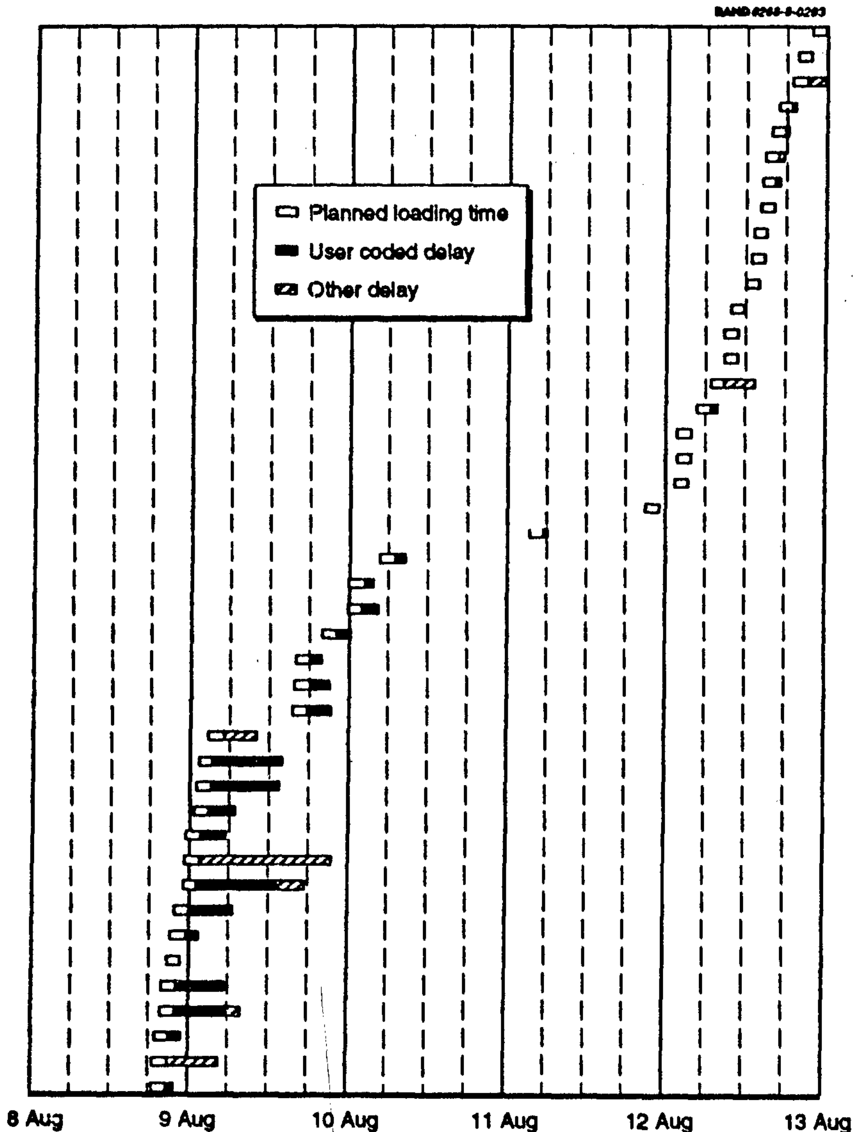
[14]In the MAIRS database, these are delays coded in the 180, 190 series (e.g., 181, 199). In particular, they include the delay "load not ready."

[15]Furthermore, there were other users, and MAC could serve the community as a whole better by providing the airlift elsewhere.



SOURCE: MAIRS

Figure 7—82nd Airborne Airlift Missions: 12–15 August 1990



SOURCE: MAIRS

Figure 8—1st TFW Airlift Missions: 8–12 August 1990

Fighter Wing represented arguably the best-prepared units for deployment in the United States military. If they had difficulty maintaining the pace required by half-hourly airlift missions,[16] other units could certainly expect trouble.

Many Units Not Prepared for Mobility Operations

The first units that deployed—the 82nd Airborne Division, Air Force units, and the Marine Expeditionary Brigades—were experienced, trained, and equipped for rapid deployments. Unfortunately, most other units were not fully prepared. For many units, the databases with transportability information on unit equipment were out-of-date or non-existent. Most did not have transportation feasibility studies. People made up the plans as they went along. The job got done, but frequently missions were postponed or delayed at the on-load station as a result of problems the deploying units had in preparing to deploy.[17]

Similar problems arose for the airlift system in Phase II. Most of the units to be deployed in December and January had not been trained to deploy. For example, the VII Corps was organized to *receive* deploying units as part of its mission in NATO, not to deploy itself, and certainly not to deploy outside NATO to a desert environment. Yet now it faced just that challenge. Many units deploying from CONUS in Phase II were reserve units with little or no mobility experience. This lack of experience caused substantial delays in moving units.

No Clear Point of Contact for Transportation at Many APOEs

Since virtually no unit had a reliable transportation plan, airlift requirements for units changed frequently as the units reassessed their needs and priorities. The result was that airlift data in the JOPES database were almost always wrong. The lift requirements entered

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[16]In defense of the users, they often had no notification of what type of aircraft was coming or when it was coming. A changed or unexpected aircraft could result in the need to reconfigure pallets and redo load plans, which is a lengthy affair.

[17]Interviews with transportation planners at XVIII Airborne Corps and with MAC staff. These problems are also cited in *Conduct of the Persian Gulf War: An Interim Report to Congress*, p. 3-2.

were often off by tens of percents. To plan airlift operations and avoid wasting assets, MAC needed a reliable estimate of movement requirements: how much equipment and of what type, to move when and to where. To ensure that it had this information reliably, MAC resorted to communicating directly with the units involved. The MAC CAT established a cell, called the Requirements Augmentees, which had the sole duty of verifying the real requirement for each Unit Line Number (ULN) in the TPFDL. They amassed telephone directories for every base and called each unit set to deploy to find someone who could confirm what the unit had to move. The system worked most of the time but was complicated by the variety of organizational structures among units. Units are not consistent in assigning responsibility to a particular office for mobility operations. It often took a dozen or more calls to find someone who had knowledge or responsibility in the area, and sometimes that person in fact did not really speak for the unit.

The Requirements Augmentees greatly reduced the inefficiencies that could have otherwise resulted. However, they were ultimately hampered by the lack of a clear point of contact at each base with responsibility for transportation.[18] This situation led to inefficiencies in the allocation and use of airlift.

Too Few Offload Bases

Airlift operations were constrained because operations were largely limited to a single airfield: Dhahran. Although Saudi Arabia has many large airfields, they did not all have the infrastructure necessary to support large airlift operations—large fuel supplies, hydrant refueling systems, material-handling equipment.[19] MAC had to fly in much of this equipment to maintain the airlift flow, and the Commander of Airlift Forces (COMALF) in-theater spent a great deal of energy keeping the airfields operating at full capacity. In the first month of deployment, Dhahran handled 59 percent of all airlift missions, or about 32 aircraft per day. The rest of the missions were

[18]The Corps Support Commander (COSCOM) in Europe did set up such a system to support deployments and it seems to have alleviated many of these problems.

[19]Brigadier General Edwin E. Tenoso, "Address to Air Force Association Briefing Session (AFABS) VII," Saint Louis, Missouri, 2 August 1991.

scattered among Riyadh (8 percent), Jubail (8 percent), and various smaller airfields (primarily for deploying Air Force units). The situation changed very little during the first four months of the deployment; through the end of November, 46 percent of all mission had offloaded in Dhahran, followed by Riyadh (9 percent), Jubail (5 percent), and King Fahd International (5 percent). The monthly totals are shown in Table 6.

Unfortunately, Dhahran could normally handle only about 30 missions per day, because of infrastructure limitations and the other uses being made of the airfield. In Phase I, this rate was manageable. During Phase I's peak month of September, MAC flew 65 missions per day into the theater; MAC achieved this increase mostly by adding more missions into King Fahd International (from 2.7 to 6.6 per day), Riyadh air base (an extra 2.6 missions per day from August levels), and increasing traffic to several other bases (for an additional 4.4 missions per day). Figure 9 shows the average daily missions by base.

For Phase II, these limits proved too severe. To meet the deadline to deploy all offensive combat units by 15 January 1991, almost 100 missions per day would need to flow through the theater. To achieve this higher throughput, MAC devised a four-part strategy:

- Request that CENTCOM move more non-airlift functions from Dhahran.
- Open up more airfields to strategic airlift operations.
- Move more missions—particularly passenger missions—to other airfields.
- Reduce on-ground times.

None of this was new, since MAC and the COMALF had been working on these issues since the beginning. Delays at offload bases were small compared with delays at onload and enroute bases, as shown in Figure 10. With the Phase II requirements, MAC had even greater impetus to achieve these goals, and met considerable success. Through a combination of reducing ground times and moving functions elsewhere, MAC was able to flow 39 missions per day through Dhahran in December and January. The flow at Riyadh for the same

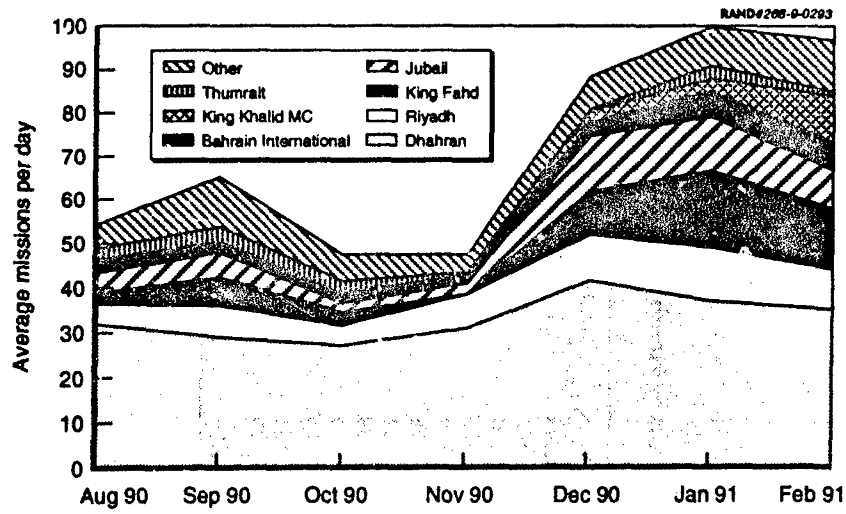
Table 6

Airlift Sorties Arriving at Southwest Asian Airfields by Month

Base	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
Dhahran	957	870	819	933	1,243	1,112	1,043	6,977
Riyadh	132	209	134	213	307	349	276	1,620
King Fahd International	81	197	84	10	300	533	413	1,618
Jubail	127	156	52	74	379	375	259	1,422
Bahrain International	92	64	54	44	100	168	190	712
King Khalid Military City	0	17	7	11	76	97	327	535
Thumrait	68	100	91	21	14	80	39	413
Shaikh ISA	58	48	20	29	38	42	66	311
Taif	35	80	29	18	9	44	70	285
King Abul Aziz	7	7	11	16	20	43	93	197
Al Dhafra	34	52	29	6	31	14	29	195
Other	24	112	52	46	75	83	91	540
Total	1,619	1,944	1,421	1,425	2,639	2,991	2,896	14,935

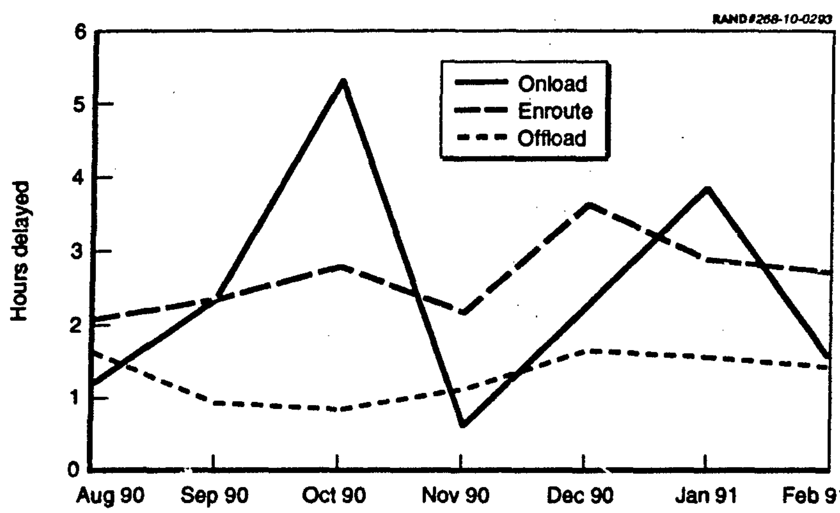
SOURCE: MAIRS.

NOTE: Totals are calendar months.



SOURCE: MAIRS

Figure 9—Offload Missions in Theater, by Base



SOURCE: MAIRS

Figure 10—Delay Times at Onload, Enroute, and Offload Bases

period was 11 missions per day, almost doubling the rate of 5.7 in Phase I.

CENTCOM and the COMALF opened up more airfields, particularly King Khalid Military City.[20] Opening airfields was only part of the problem. MAC had to persuade the deploying units and their parent commands to use fields other than Dhahran. For instance, in late November, the Army was still requesting that over 75 percent of its missions go to Dhahran. By December, MAC succeeded in moving a significant number of passenger missions to other fields, principally King Fahd and Jubail; in December and January, these airfields averaged 26 missions per day, compared with 8 per day in Phase I. This left Dhahran primarily for cargo offloads. Figure 9 shows the average number of missions per base per day. It clearly suggests the critical role these bases played in providing additional throughput. All together, four airfields handled 78 percent of all the missions: Dhahran, Riyadh, King Fahd, and Jubail. Table 6 provides the total missions by month from August 1990 through February 1991.

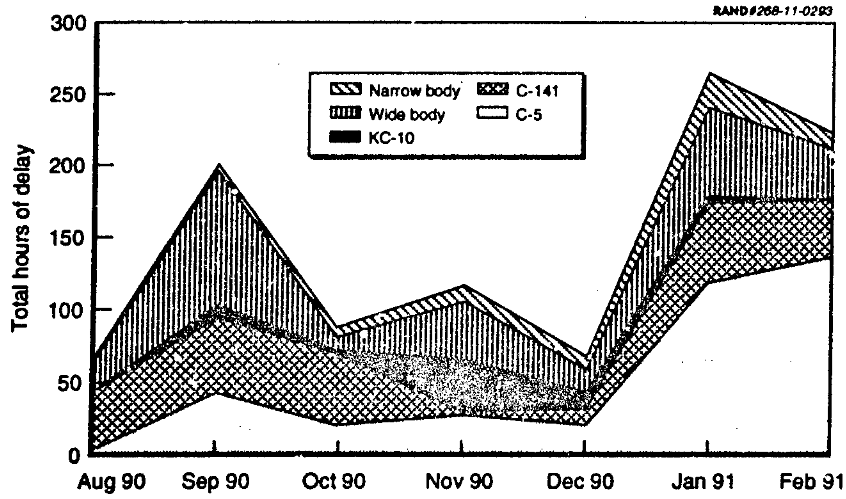
This experience highlights the necessity of a sound airlift infrastructure and access to bases to support a massive airlift flow. It also emphasizes the importance of having the ability to expand aerial port capacity through deployable material-handling equipment and having aircraft that can best use the limited infrastructure available.

Problems with Material-Handling Equipment and Pallets

Insufficient and unreliable MHE and congestion at the pallet yards hampered both loading and unloading operations. There were not enough pallets. The amount of resupply cargo exceeded expectations, and pallets became in short supply. Many pallets were transported from the airhead directly to the user, because it was faster to load the entire pallet on a truck than to unpack the pallet and load individual items. Getting pallets back from the user, some of whom were 300 miles away, proved difficult. Returning pallets to CONUS became a full-time effort involving around-the-clock shifts. In November alone, 50,000 pallets were returned to CONUS.

[20] King Khalid Military City was used in Phase I, but at a very low level.

Condition of the MHE was an even greater issue. The biggest problems were 40K loaders for organic aircraft and the wide-body loaders. Both pieces are 1960s technology and prone to break down. In the Saudi climate, seals and gaskets were a particular problem. Some of the wide-body loaders had been put into long-term storage and took time to return to working order. As Figure 11 shows, the total times for mission delays attributable to MHE were relatively small for the scale of the operation. However, this delay fails to show the whole picture.[21] MHE problems did slow down the airlift flow by restricting the maximum number of aircraft that could be handled at a base at a given time. The MAC CAT flow cell would reduce the flow through a base if MHE constraints were reported. Unfortunately, we have no way of measuring this effect.



SOURCE: MAIRS

Figure 11—Total Delays Due to MHE

[21]It also shows a picture the reader and authors would prefer not to see: likely errors in the MAIRS database. It is improbable, for instance, that the C-5, which requires only a single piece of MHE, would have a much higher percentage of the error (in January and February) than CRAF and the KC-10, which each require two pieces of MHE.

Congestion also contributed to the delays. Initially, the square footage of tarmac available for pallets at Dhahran would hold only about 50 pallets, or roughly one and one-half C-5 loads. Subsequently, the area was extended to hold about 2000 pallets. Cycling pallets through the pallet yard proved to be another bottleneck. The yard was receiving about 500 pallets daily but sending out only 300. Pallets bound for units whose TPFDL priority had slipped had no place to go. At one point, 1300 pallets were queued in the yard awaiting delivery because there were not enough loaders and trucks to move the palletized cargo.[22]

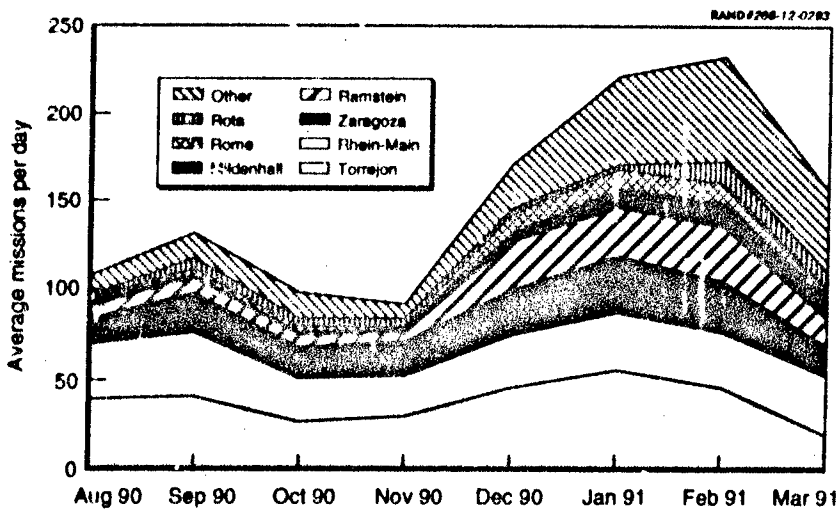
Interbase Communications in Short Supply

The communications networks lacked adequate capacity. At the 22nd Army Component Commander, Central Command (ARCENT) support command in Dhahran, for instance, a single, dial-out, STU III phone serviced 120 people (a second STU III was attached to a telefax machine). Commercial phone lines, which appear to have been plentiful and reliable in the theater, could have, with more STU IIIs, opened up communciation channels.

Too Few Enroute Bases

Another major constraint on the airlift flow was the number of enroute bases. The principal enroute bases were subject to heavy traffic—they received aircraft both going to and returning from the theater. (Compare the average daily flow in Europe, Figure 12, with the flow in the theater, Figure 9.) From August through March, four bases handled 75 percent of the flow: Torrejon (29 percent), Rhein-Main (21 percent), Zaragoza (16 percent), and Ramstein (9 percent). Torrejon even surpassed Dhahran in the number of sorties going through the base; Rhein-Main ranked third. MAC did not choose these bases arbitrarily: no other bases in Europe had the combination of facilities (ramp space, refueling systems, maintenance, crew

[22] Interview with Colonel William Taylor, who was the Senior Military Airlift Command representative at Dhahran.



SOURCE: MAIRS

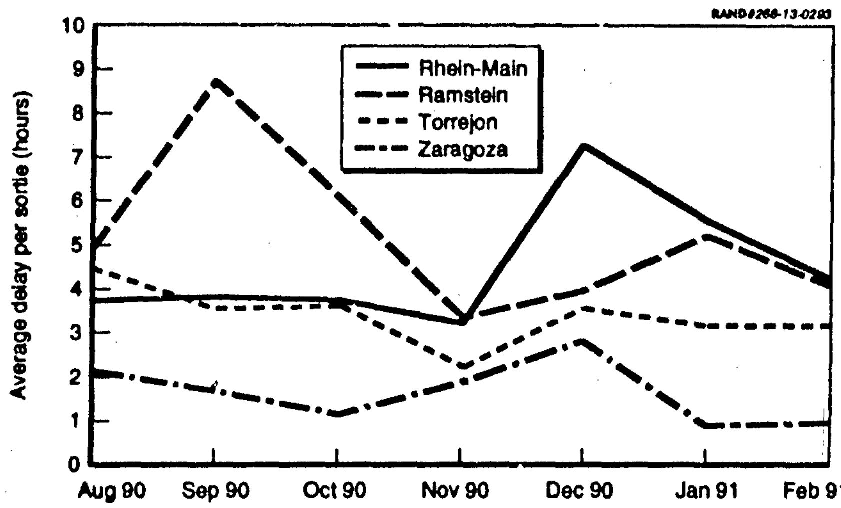
Figure 12—Sorties Flown Through European Enroute Bases

quarters) necessary to handle a flow of this magnitude[23] or were the proper distance between CONUS and the theater.[24]

Clearly, any problems encountered at these bases would affect the entire flow. Conversely, any delays in the theater would cause a backup in Europe. The extent of the problem with delays at key enroute bases can be seen in Figure 13. At Rhein-Main, missions were

[23] Some interview data indicated that numerous sorties through Rhein-Main could have been handled at Ramstein. We did not analyze this aspect, although it certainly is a consideration that planners should investigate. Although Ramstein might offer an alternative, it too suffers from limitations in capacity. In particular, the runway cannot handle a C-5, and increasing capacities of military facilities in Germany is always difficult.

[24] Bases in Italy are too far from CONUS and would have required offloading cargo in exchange for fuel. Bases in England are too far from the theater, for if there are no stage bases in the theater, the round-trip journey could exceed the limits of even an augmented crew duty day if there are delays. (The United States did, however, use Mildenhall and Upper Heyford, and there are those who would argue that there was more room at Mildenhall, and that Fairford would have made an ideal enroute base.)



SOURCE: MAIRS

Figure 13—Average Delays at Key Enroute Bases

typically delayed 8.5 hours and at Ramstein 9.0 hours.[25] Delays became worse as weather and air traffic control problems mounted.

Stage operations at the enroute bases were initially unorganized. This is attributed to the fact that MAC no longer runs a stage operation for peacetime, channel flights, so personnel at command posts in Rhein-Main and Torrejon, for instance, lacked the necessary experience.

Restrictions at German Civilian Airfields Slowed Operations

Yet another base constraint was the limits on commercial flights at several German civil fields used for the deployment of personnel from VII Corps. German authorities restricted nighttime operations at several civil airfields for noise abatement. For instance, Nürnberg was a major APOE for the deployment of the VII Corps, but flights

[25]The average delay per sortie was 4.25 hours at Rhein-Main and 4.5 hours at Ramstein, but typically a mission included two sorties through enroute bases.

were prohibited at night and restricted during twilight hours. Furthermore, since civil fields were used, MAC had to share slot times with normal civil traffic, which constrained the slots available for flights to the AOR.

AIRCRAFT PERFORMANCE

The last general problem area is the performance of individual aircraft: the C-5, the C-141, and CRAF. We next discuss problems or issues involved with each of these aircraft.

Delays Resulting from Maintenance and Supply

An examination of delays in the MAIRS database reveals that every ODS mission[26] was delayed 10.5 hours on average. Although many factors contributed to these delays, logistics was the single greatest cause, accounting for 40 percent of the total time delayed (see Figure 14).[27]

The C-5 in particular was plagued by logistics delays. During the period August through February, C-5 missions were delayed on average 9.0 hours per mission because of logistic problems alone, compared with 4.3 hours for the C-141. Figures 15 and 16 show the average delay per mission by month;[28] they are drawn to the same scale to facilitate comparison.

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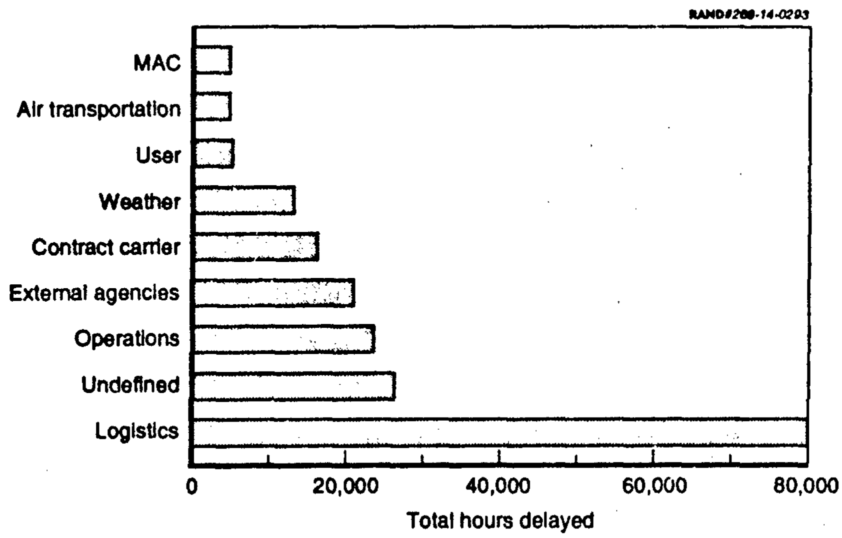
[26]An ODS mission consisted of 4.9 sorties on average.

[27]Logistics delays are those coded 700 through 998 in MAIRS. These include the categories of Supply, General Maintenance, Configuration/Reconfiguration, Aircraft Servicing, Saturation, Shop Repair, Airframe, Power Plant, Systems, Communications, and Navigation Aids. Definitions for some of the other delay categories are: "MAC" refers to delays directed or validated by MAC to improve overall mission efficiency; "Air transportation" refers to processing, loading, and unloading of passengers and cargo; "External agencies" includes a wide spectrum of causes ranging from enemy action to noise abatement; "Contract carrier" is a catch-all for CRAF aircraft, including everything from sick crew members to aircraft mechanical problems.

[28]In the MAIRS database, delay times and delay causes are entered, but the times often fall well short of the delay one calculates by computing the difference between expected and actual (arrival or departure) times. A possible explanation is that MAC adjusted arrival times as it realized the schedule was slipping, but did not update the database. In consultations with MAC we therefore decided that the most faithful representation of delays would be based on a calculation that is *independent of the actual schedule*. We compared the time spent on the ground (actual departure time minus



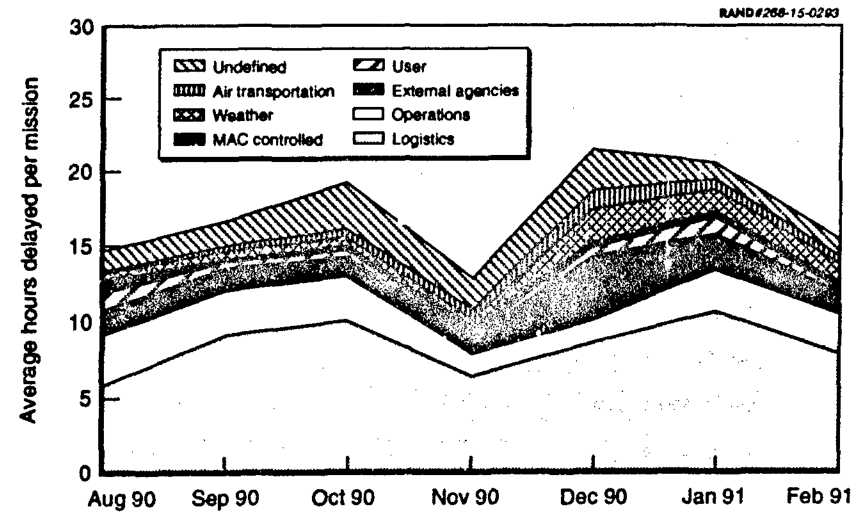
SOURCE: MAIRS

Figure 14—Total Delays by Category

Normal cycle times for missions (a cycle begins when a fully loaded plane departs its APOE and ends when the plane recovers at the original base or at a recovery base), assuming no maintenance or other stops, should be about 60 hours. This may include six or seven sorties.[29] With an average delay of 18.3 hours per mission, cycle times for C-5 missions increased substantially and utilization decreased. The high rate of logistics delays for the C-5 warrants closer examination.

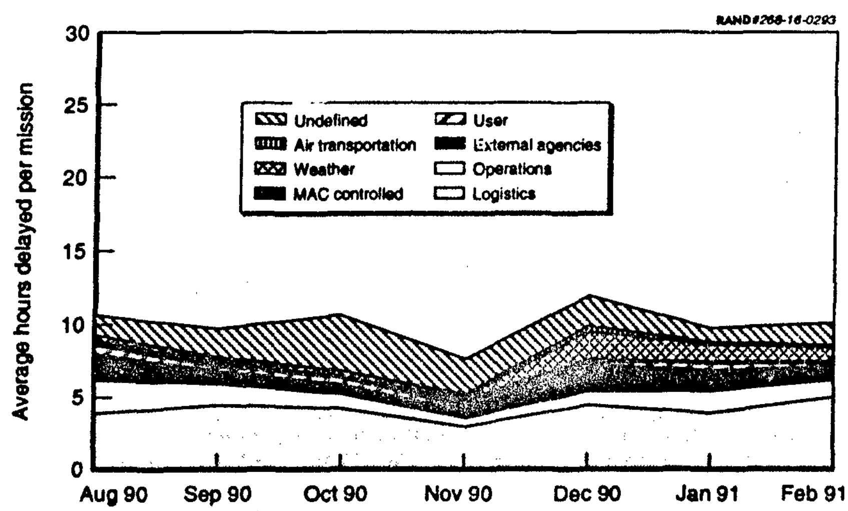
actual arrival time) to time on ground as dictated by the planning factors and assigned the difference to the delay category specified in the (primary) delay code field. A problem with this method is that if MAC consciously scheduled an on-ground time greater than the time specified in the planning factors, we calculate a delay but have no category to assign it to. In this case, or in the case in which we do not recognize the category code indicated, we refer to the delay as "Undefined."

[29]Seventy-five percent of the missions had six sorties or less; 90 percent had seven sorties or less.



SOURCE: MAIRS

Figure 15—C-5 Average Mission Delays



SOURCE: MAIRS

Figure 16—C-141 Average Mission Delays

Percentage of C-5s and C-141s Available

Operation Desert Shield marked the first time that the United States fully used the C-5 fleet. With a large portion of the fleet in the reserve component, and with the low peacetime flying regime, the Air Force had never exercised the entire C-5 fleet hard. With the sudden surge in activity, a number of problems emerged with the system. As shown in Table 7, the percentage of aircraft available[30] declined steadily from the onset of the operation. By late October, rates were as low as 50 percent. The average delay per mission due to logistics rose from 5.7 hours to 10.1 hours. At main ports, ramp saturation made it difficult to move necessary support equipment to the troubled planes, exacerbating the problem. But while some of the delay may have resulted from ramp congestion, maintenance problems appear to have been the major contributing factor.

Table 7

Percentage of Aircraft Not Available: Phase I

Reason	Daily averages			
	August	September	October	Average
C-5				
Due to maintenance	10.7	18.4	20.6	17.1
Due to supply	8.4	8.6	9.9	9.0
Due to both	1.7	1.7	3.7	5.8
Total	20.8	28.7	34.2	31.9
C-141				
Due to maintenance	8.0	10.7	11.4	10.2
Due to supply	3.7	4.1	4.0	4.0
Due to both	0.9	0.9	2.4	1.5
Total	12.6	15.7	17.8	15.7

SOURCE: MAC/XPY.

NOTE: Values are for calendar months.

[30]Official mission-capable (MC) rates apply only to aircraft in CONUS, and although MAC/LG did track the number of aircraft in the system, worldwide, that were operational, it is a misnomer to refer to these data as mission-capable rates. Therefore we use "percentage of aircraft available" and "percentage of aircraft not available."

Project AIR FORCE is still examining the maintenance data to understand why this occurred. Our best hypothesis now is simply that many aircraft had problems that had not fully emerged in normal operations.[31] These undiscovered problems led to the increasing number of aircraft being declared unavailable due to maintenance troubles. Whereas in August, an average of 11 percent of the C-5 fleet was not available due to maintenance, by October the average was 21 percent and on some days reached 50 percent. Aircraft declared unavailable due to supply increased slightly from 8 to 10 percent, while those declared unavailable due to both maintenance *and* supply increased from 2 to 4 percent (probably due mostly to maintenance). The C-141 aircraft declared unavailable due to maintenance grew from 8 to 11 percent, those declared unavailable due to supply remained unchanged at 4 percent, and those unavailable due to both maintenance and supply grew from 1 to 2 percent. The percentage of aircraft that were unavailable increased in October as MAC took the opportunity presented by the reduced airlift requirements to catch up on deferred maintenance.

On a more positive note, the relatively low percentage of C-141s and, to a lesser extent, the C-5s that were not available was a direct result of the significant stockpiles of spares procured during the 1980s for the C-141B and C-5A. These stocks helped MAC to maintain a higher operations tempo than would have been otherwise possible.

Going into the accelerated operations for the Phase II deployments, MAC was concerned that the C-5 availability rate would continue to decline. As seen in Table 8, the C-5 actually maintained a fairly steady rate of 33 percent unavailable. Although still a high rate, MAC could find some comfort in its stability compared to Phase I. The fact that it stabilized at about 33 percent (±5 percent) came as something of a relief. Only in late March, after the war, did the rate begin to climb again, and then because of MAC's decision to start deferred

[31] Project AIR FORCE does not yet have a detailed breakdown of the maintenance data. However, from MAIRS we can say that 37 percent of the logistics delays were due to systems, 21 percent to airframe, and 17 percent to power plant. Problems in these areas added 6.8 hours on average to each mission. The breakdown for the C-141 was similar, but with more airframe problems: 31 percent of the logistics delays were due to systems, 25 percent to airframe, and 20 percent to power plant. However, average delays were half those of the C-5: 3.4 hours per mission.

Table 8

Percentage of Aircraft Not Available: Phase II and the War

Reason	Daily averages					
	November	December	January	February	March	Average
C-5						
Due to maintenance	18.6	18.0	18.4	18.5	19.2	18.5
Due to supply	8.6	9.9	11.4	9.6	8.7	9.7
Due to both	7.8	3.4	2.4	4.0	4.9	4.5
Total	35.0	31.3	32.2	32.1	32.8	32.7
C-141						
Due to maintenance	13.0	9.3	7.7	10.5	13.4	10.6
Due to supply	4.1	5.0	5.2	4.4	4.8	4.7
Due to both	3.8	2.1	0.9	2.4	3.7	2.5
Total	20.9	16.4	13.8	17.3	21.9	17.8

SOURCE: MAC/XPY.

NOTE: Values are for calendar months.

maintenance. Likewise, the percentage of C-141s unavailable remained stable at about 18 percent (±4 percent). This rate was only slightly higher than Phase I's 16 percent. During the critical period from mid-December through the end of January, MAC was able to bring the percentage of aircraft unavailable down to an average 14 percent. However, this meant a higher rate in February and March.

Although the percentages of C-5s that were unavailable were high, the real policy issue is: Did it matter? If these aircraft were not needed, one need not worry whether they were available. After the fact, Project AIR FORCE has found it extraordinarily difficult to pin down the "real" requirement. The linkage between requirements and capability runs both ways: not only do capabilities change to meet requirements, but when capability declines over time, planners adjust their expectations and reduce requirements. Therefore, one cannot reconstruct the definite, "real" requirement after the fact.

In an attempt to get an estimate of this problem, we compared the number of scheduled ODS missions per day with the number of aircraft available each day, recognizing that MAC CAT planners established schedules before they could be certain how many aircraft would be in operation. Figures 17 and 18 show the results for Phase I

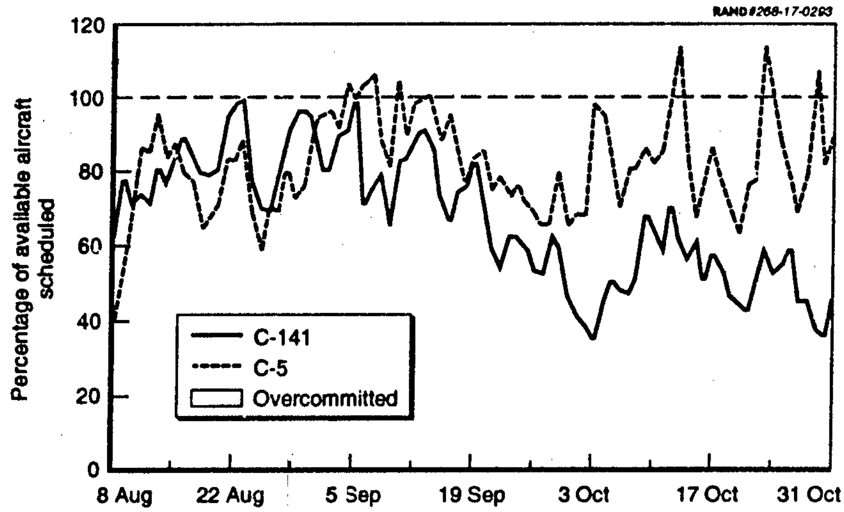


Figure 17—Missions Scheduled Versus Aircraft Available: August–October 1990

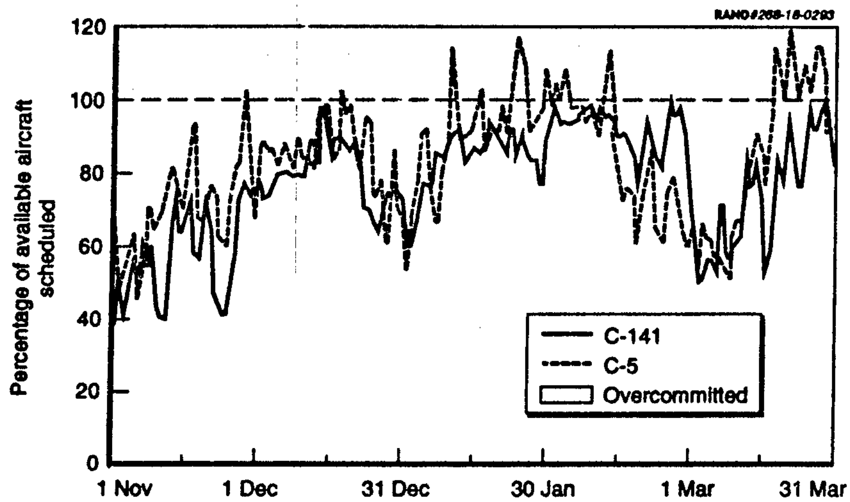


Figure 18—Missions Scheduled Versus Aircraft Available: November 1990–March 1991

and Phase II/III, respectively. These graphs display the number of ODS missions scheduled as a percentage of the available aircraft for August through March. As can be seen, a clear excess in demand for C-5s over supply can be found in late August, in early September (when the 101st Airborne was being deployed), in October (when the percentage of C-5s that was not available was exceptionally high), and most especially in the early weeks of the war (when MAC deployed Patriots to Israel and Turkey and heavy equipment transporters for the Army to Saudi Arabia). In the weeks leading up to the war, the C-5 was close to being 100 percent committed to ODS. Although the C-141 was heavily used at times, it was never overscheduled as was the C-5.[32]

Another way to look at this problem is to reconsider the UTE rate issue. As shown earlier in Figure 2, the UTE rate for the C-5 was particularly low. An argument we have heard is that utilization was low because MAC simply did not use the aircraft available. The evidence for this argument is that capable but unused aircraft were reported available on most days of ODS. One way to address this question is to consider the USE rate for all aircraft that were available, whether or not they were flown. MAC defines USE rate as "A measure of a single aircraft's capability to generate flying hours expressed in average flying hours per aircraft per day. As opposed to the utilization (UTE) rate, the USE rate is computed only for those aircraft (usually mission capable) applied to a specific mission" [Air Force Pamphlet AFP 76-2, p. 27].

Figure 19 presents these results. The USE rates for "available"[33] C-5s and C-141s were still below planned surge UTE rates in Phase I, but they come close to the planned sustained rates in Phase II. The

[32]This approach actually overestimates the availability of the aircraft. Rarely would one expect 100 percent of all aircraft to be available when and where needed. MAC must still fly non-ODS missions. An aircraft may break down in one part of the world, with the only available replacement too far away to be useful. Perhaps most important, the number of aircraft scheduled depends in large part on the aircraft's reliability. Each time that the MAC CAT directors found that the C-5 fleet was not able to generate enough aircraft to meet the demand, they would direct the flow cell to reduce the number of C-5 missions scheduled per day. Thus, over the course of the deployment, the flow cell adapted from trying to schedule roughly 32 C-5 missions per day to scheduling about 18.

[33]This is admittedly a corruption of the concept of USE rates, since it includes aircraft not applied to the specific mission.

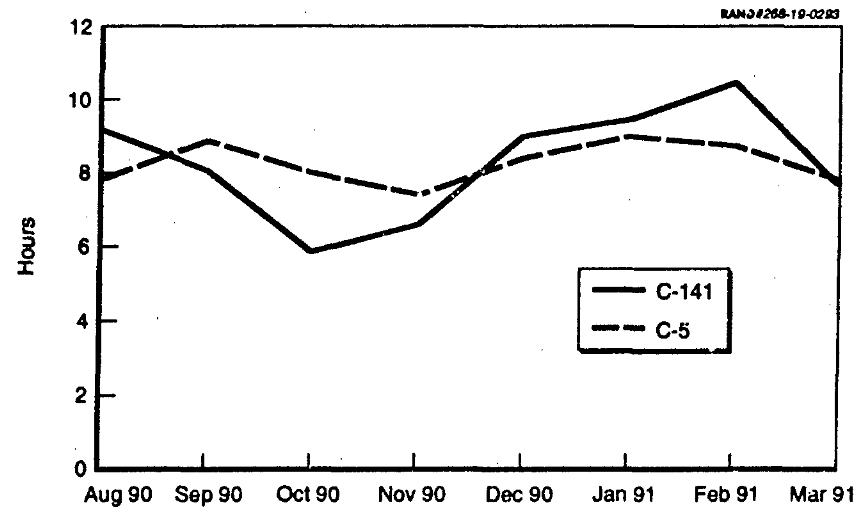


Figure 19—USE Rate of Available C-5s and C-141s

C-5 rate was fairly steady throughout, peaking at a USE rate of nine hours in January. This lends more credence to the argument that the C-5s that were working were used extensively, and that the low UTE rates may be explained to a fair degree by the higher than expected rates of unavailable aircraft.

This analysis still leaves unanswered the question of whether the high quantity of unavailable C-5s really mattered or not. In our opinion, the weight of evidence supports the proposition that the C-5 was more than fully utilized, given all the problems with the aircraft and with the airlift system. At times, the C-5 fleet could not fly all the missions scheduled. This suggests that sometimes MAC did not have enough outsize capability to meet CENTCOM's goals. However, this proposition cannot be proven based on the data available to us.

C-141 Payload Limits

One of the more striking shortfalls in performance was the low average payload for the C-141. For a deployment with a critical leg of

roughly 3500 miles[34]—as in ODS—published planning factors indicate a wartime payload of about 25.6 short tons.[35] In ODS, the C-141 averaged only 19 short tons, a shortfall of 26 percent. In other words, if the C-141 fleet could have averaged planning factor payloads, it could have delivered 35 percent more cargo.

We considered a number of possible explanations for this phenomenon:

- Environmental factors—enroute winds, temperature, pressure altitude, and adverse weather at onload locations, enroute locations, and in the theater—reduced the payload that could be carried.
- Peacetime, rather than wartime, payload limits were used.
- Lighter payloads were deliberate, to retain sufficient fuel in the event that the aircraft had to loiter or divert.
- The lower average payload merely reflected lighter-than-anticipated loads.
- A hard limit was imposed because of fatigue problems with the aircraft.[36]

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[34]Some typical distances (in nautical miles):

Base	Torrejon	Rhein-Main
McGuire	3240	3502
Dover	3296	3534
Charleston	3710	3877
Pope	3486	3745

The effective distances would be lower enroute to the Gulf because of prevailing tail winds.

[35]This assumes wartime planning factors from Air Force Pamphlet AFP 76-2 and arbitrarily assumes half oversize and half bulk cargo.

[36]For more on this problem, see the section on the C-141 service life that opens Chapter Four.

We will explore each of these possibilities carefully, since they have important implications for the future. If the problems were environmental, specific to the time and place, then one can draw few lessons for future operations. If the uncertainty of the mission induced crews to carry conservative fuel loads, AMC needs to reassess its reserve fuel requirements (at the same time that it continues work on containing delays). If the problems resulted from the nature of the cargo, then AMC may need to reassess its planning factors and its assessment of airlift capability. If the problems were specific to the C-141 airframe, then that airframe must be fixed or replaced.

Each of these explanations has problems. Environmental factors could easily dictate lower allowable cabin loads. For instance, if winds enroute to the theater—tail winds when flying from CONUS to the theater—were less than normal, the effective critical leg would be longer, thus forcing a lighter load. However, although this might explain lower allowable loads for a limited period of a few weeks, it seems unlikely that abnormal tail winds would prevail over a seven-month period, covering the height of summer to the depths of winter.

The hypothesis that peacetime rather than wartime limits were used[37] also fails to fit the data. Assuming it were correct, the payloads would differ depending on the lengths of the routes and would correspond to peacetime limits. A McGuire-to-Torrejon sortie, for instance, at 3240 nautical miles, would correspond to a payload of 23 short tons.[38] Unfortunately, the data do not concur: not only are many individual payloads above peacetime limits for their respective routes, but at least for one base the *average* payload is above maximum peacetime payloads.

The argument that crews carried less cargo and more fuel in the event that they might have to divert or loiter instead of landing promptly fails because planning factors are not determined based on maximum fuel (for a given distance). Reserve fuel, for loitering, for instance, is deducted before that calculation is made. It is true that the aircraft did often have to loiter, sometimes for 30 and 45 minutes,

[37]The maximum *peacetime* payload for 3500 nautical miles is 20.3 short tons, compared with the wartime limit of 25.6 short tons.

[38]Fully 30 percent of all the sorties with payloads over 21 short tons are from McGuire.

and it is also true that at the time the load plans were made, conditions of weather and wind for subsequent legs were unknown, but this was no more true for C-141s than it was for any other type of aircraft.

The final two explanations are more commonly cited and are in many ways contradictory. The "lighter-than-anticipated payloads" argument would be a simple explanation. Many people have correctly pointed out that almost all aircraft loads "cube out" an airlifter—fill up the available space—before they "gross out"—reach the maximum allowable cabin load. The problem is that the planning factors were intended to capture that effect. In reality, the maximum payload at 3300 to 3500 miles is not the 25.6 short tons figure cited above, but closer to 26 to 29 short tons.

Another explanation for lighter-than-anticipated payloads is that users did not have the time to plan their loads effectively. This is plausible, but again, [illegible] expect to see the same phenomenon with all the aircraft typ[illegible] just the C-141.

The argument t[illegible]t a h[illegible]nit was imposed is suggested by the data, but not conclusively. If [illegible]ard limit existed and if it were constraining, then the data should clearly show this—a distribution of payloads should rise asymptotically to the limit. If, alternatively, one believes that the payloads were merely lower on average than expected, one should see a normal shape distribution (bell curve) around the "natural," lower average. Figure 20 illustrates these concepts. The "normal" distribution assumes that the average payload is 20 short tons distributed over a range of values above and below. The "constrained" distribution assumes the same payloads would have been loaded, but that a limit of 20 short tons exists. Therefore, all the loads above that limit have to be broken down into 20-ton loads.

When we tested this hypothesis, the results were ambiguous. For certain bases, such as Pope, Dover, and Campbell, a real limit was evident. Other bases (mostly on the West Coast) just as clearly did not evidence such a limit. The case of McGuire, which accounts for almost half the sorties, is ambiguous. Overall, the distribution of payloads vaguely suggests a limit, but not definitely (see Figure 21). Appendix B presents distribution graphs for the most active bases.

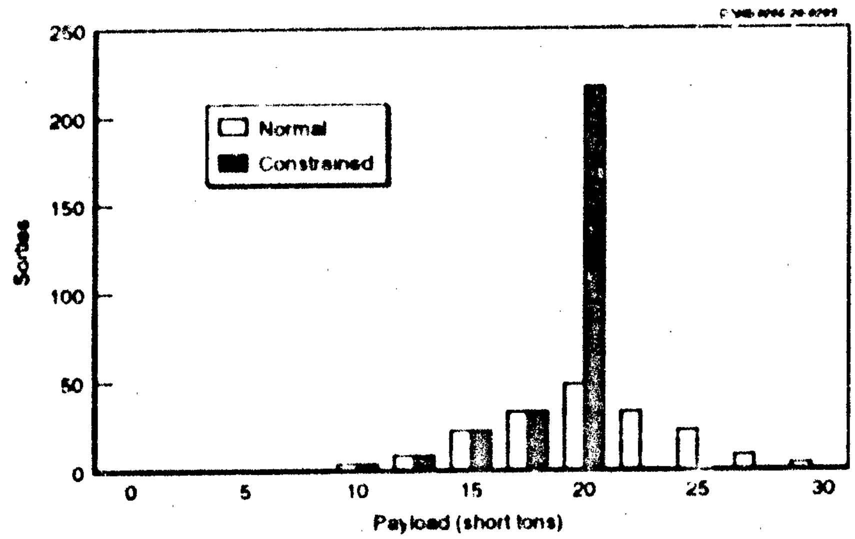
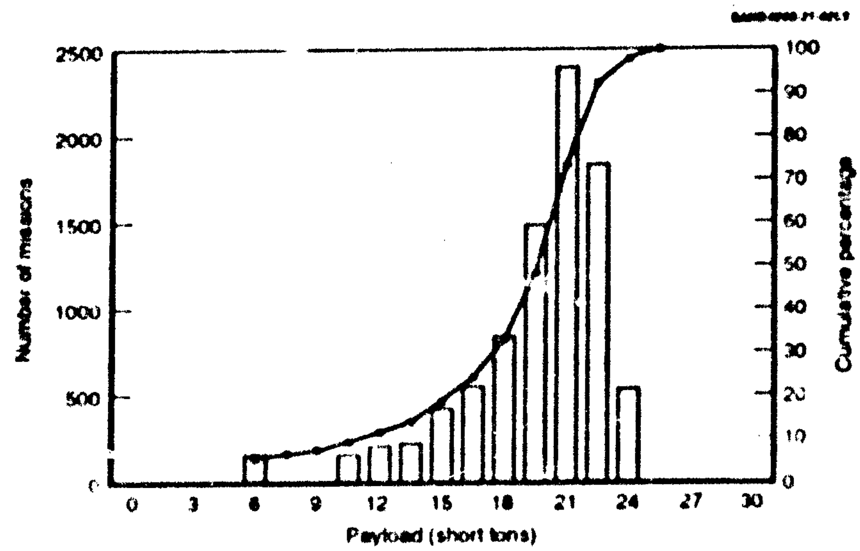


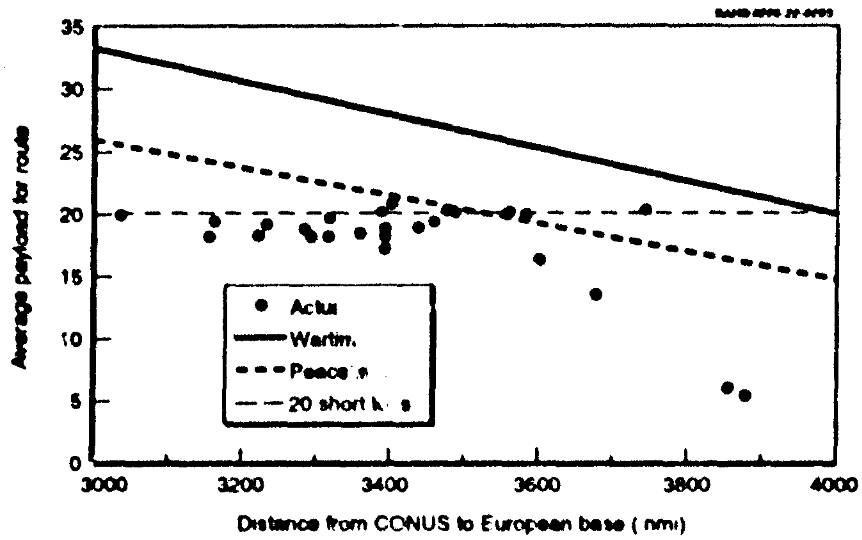
Figure 20—Illustrative Payload Distributions



SOURCE: MAIRS

Figure 21—C-141 Payload Distributions

Figure 22 shows the average payload for the 30 busiest C-141 routes between CONUS and Europe, accounting for 90 percent of all the missions.[39] The lines represent the three different possible limits: maximum payloads with peacetime limits. maximum payloads with wartime limits, and a 20 short-ton limit. The line that best fits the data is the 20 short-ton limit. The peacetime limit does not seem to apply because the average payload for at least one route exceeded



SOURCE MAIRS

Figure 22—Average C-141 Payloa from CONUS to Europe

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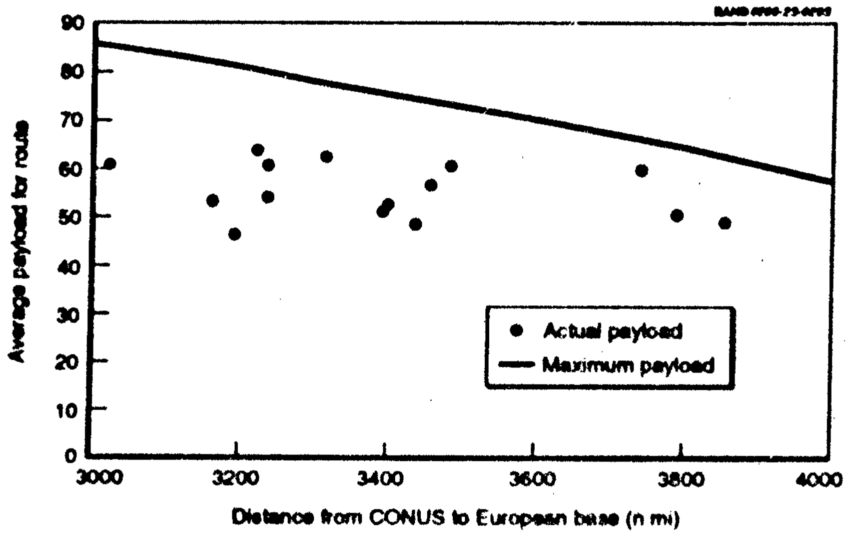
[39]McGuire was the primary CONUS base for C-1 sortiec to Europe, accounting for 50 percent of the total The three busiest legs—to Torrejon, Zaragoza, and Ramstein—accounted for 43 percent of all C-141 transatlantic sorties These fall in the 3200 to 3400 nautical mile range Excluded from this chart are the remaining 187 routes (Of these, 68 (3 percent of the total) have averages of over 20 short tons However, this is somewhat deceptive since most of these routes had only one or two aircraft Overall, 73 routes representing 10 percent of the total had payloads averaging more than 20 short tons Almost half of these sorties were flown out of Pope AFB, which averaged 20 03 short tons per sortie.

that limit,[40] although that could have been a limited experience. More generally and more strikingly, the data points do not seem to follow either the peacetime or wartime curves.[41] Indeed, the data seem to follow a flat slope, suggesting a hard limit across the range up to about 3500 nautical miles. This lends support to the hypothesis that a hard limit of 20 short tons existed. However, by itself, it could also support the hypothesis that payloads just naturally averaged about 20 short tons.

For comparison, we performed the same analysis for the C-5, as shown in Figure 23. The routes shown represent the 18 busiest,



SOURCE: MAIRS

Figure 23—Average C-5 Payloads from CONUS to Europe

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[40]The route was Pope to Rhein-Main, with 93 missions (1.3 percent of the total), for an average payload of 20.1 short tons.

[41]Rather than use the maximum payload, one could use some other limit, such as the expected bulk or oversize payload. In the case of the peacetime limits, this makes little or no difference; the maximum payload defines the expected bulk or oversize payload at these ranges. For the wartime limits, although the curves differ slightly, neither fit the data significantly better. (See AFP 76-2, *Airlift Planning Factors*.)

accounting for 90 percent of all C-5 sorties flown from CONUS to Europe. The chart suggests a much more widely scattered distribution, certainly not as concentrated as with the C-141. Indeed, it does suggests a "natural" distribution, centering around 50 to 60 short tons.

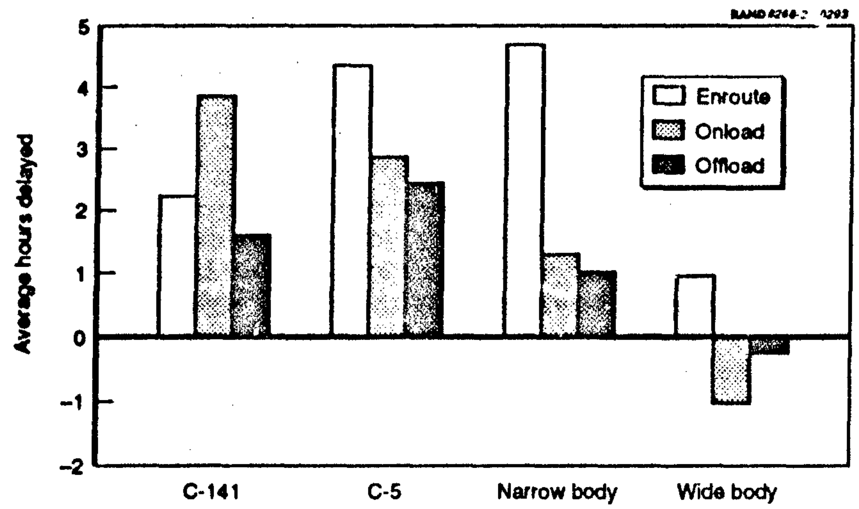
The fact that many explanations were offered, some emphatically, by parties closely involved in the operation, suggests that no single explanation tells the complete story. But we do now know the official answer. Concerns about fatigue of the aircraft, highlighted by disturbing cracks in the inner-outer wing joint of the aircraft, resulted in a directive, on 8 August 1990, that all C-141s carry a payload of no more than 22.5 short tons, and C-141s from Charleston carry 20 short tons, because of the longer distances involved. The 21st Air Force issued a response to the Concept of Operations (CONOPS), on 24 November 1990, applying the 20-short-ton limit to the entire fleet (alternatively, the users could apply for waivers for heavier loads). The November adjustment was made in an attempt to simplify the planning and loading process—this way, if planes were rerouted to a more distant base, users would not have to tear down and reconfigure their loads.

CRAF Performance

Average delays for CRAF narrow-body aircraft were similar to those for the C-141. CRAF wide-body aircraft had far fewer delays, with average ground times close to, and often better than, planning factors, as shown in Figure 24.[42] Figure 25 shows the average delays identified by cause.

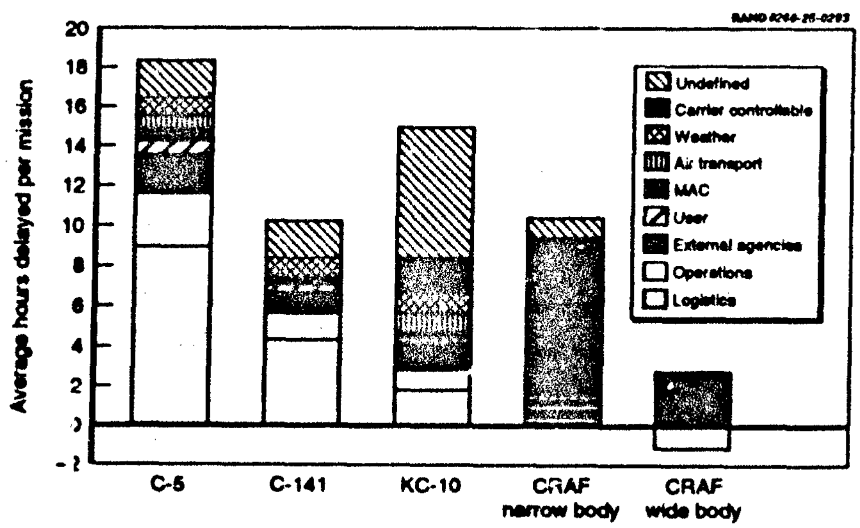
In explaining the differences in performance between organic and civil aircraft, two factors dominate. First, CRAF participants are obligated to provide a certain capability; if aircraft break down, the car-

[42]Fifty-six percent of CRAF wide-body missions were PAX missions, compared with only 11 percent for CRAF narrow-body missions; it is far easier to onload and offload passengers than cargo.



SOURCE: MAIRS

Figure 24—Delays at Onload, Enroute, and Offload Bases



SOURCE: MAIRS

Figure 25—Average Delays by Aircraft Type

rier must provide replacement capability. Thus, the CRAF aircraft show almost no logistics delays. Second, CRAF aircraft flew most of their missions in channel operations. This second point warrants further explanation.

Channel cargo is almost exclusively bulk cargo[43] and, not surprisingly, the efficient bulk-carrying aircraft took most of these missions, as seen in Table 9. The C-5 contributed the most to the movement of channel cargo, 42 percent of the total from August through February, while flying 26 percent of the channel missions.[44] In Phase I, it handled 50 percent of the total. With the start of the Phase II deployments, the C-5 carried less channel and more unit cargo; CRAF aircraft took up most of the slack. With the activation of CRAF Stage I, CRAF carriers handled about 50 percent of the cargo. Wide-body civil freighters dominated, carrying a third of the traffic in January and February. By February, almost 2000 short tons of channel cargo was being flown to the theater every day.

Because CRAF freighters are so efficient at carrying bulk cargo and because the carriers preferred flying the regularly scheduled operations offered by channels, MAC assigned CRAF freighters almost exclusively to this role. Table 10 shows, for each aircraft type, how much of all the cargo that they carried was in channels. It indicates that by December civil aircraft came to be used almost entirely in channel traffic. Even wide-body passenger aircraft were used extensively in channel missions at the end, when few major passenger moves remained. The KC-10 was also used primarily in channel operations, although it dual-use capability (tanker and airlifter) made

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[43]*Bulk cargo* is cargo that can fit within the usable dimensions of a standard 463L pallet: 104 inches long and 84 inches wide, with cargo loaded up to 8 feet high. MAC assumes an average pallet load to weigh 2.3 short tons. Cargo that exceeds the dimensions of a 463L pallet but can still fit in a C-141 (that is, it is less than 1090 inches long, 117 inches wide, and 96 inches high) is categorized as *oversized*. Cargo that exceeds those dimensions but can fit on a C-5 is called *outsized*.

[44]The C-5 can carry up to 36 standard 463L pallets; the C-141 can handle 13. By contrast, B-747 freighters can carry up to 46 pallets, depending on the configuration; with its superior range-payload performance, it can easily carry a full load of pallets for typical deployment distances. Thus, one B-747 could handle the same amount of bulk cargo as three or four C-141s, at least when flying between major airfields with substantial facilities.

Table 9

Sustainment Cargo (Short Tons) by Aircraft Type

Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
Organic								
C-5	722	6,320	11,685	19,307	16,711	11,957	16,806	66,701
C-141	1,286	1,103	3,830	7,540	10,181	9,499	10,597	33,439
KC-10	117	1,443	1,797	1,599	3,019	1,089	0	9,064
Organic subtotal	2,125	8,866	17,312	28,446	29,911	22,545	27,403	109,204
CRAF								
Narrow body: Cargo	0	623	906	1,702	3,176	6,445	8,210	12,851
Narrow body: PAX	0	0	96	108	155	448	437	807
Wide body: Cargo	124	4,454	3,749	5,617	7,779	13,896	19,837	35,619
Wide body: PAX	86	0	0	52	180	277	2,155	594
CRAF subtotal	210	5,077	4,751	7,479	11,290	21,066	30,639	49,871
Total	2,335	13,943	22,063	35,924	41,201	43,610	58,042	159,075

SOURCE: MAC/XPY.

NOTE: Totals are for 30-day periods.

Table 10

Sustainment Cargo as Percentage of Total for Each Aircraft Type

	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91
Organic							
C-5	3	20	45	74	49	28	50
C-141	7	6	32	58	39	30	37
KC-10	21	42	97	96	88	81	0
CRAF							
Narrow body: Cargo	0	27	72	84	99	100	100
Narrow body: PAX	0	0	100	80	100	100	100
Wide body: Cargo	8	63	95	96	97	95	100
Wide body: PAX	2	0	0	3	1	2	41

SOURCE: MAC/XPY.

NOTE: Values are for 30-day periods.

it an ideal choice for supporting fighter deployments in August and September;[45] once the war had begun, the KC-10 was withdrawn for theater operations. The organic airlifters—the C-5 and C-141—mainly supported unit moves, but still flew a significant portion of their missions on channels. The C-5, with its large bulk capability, would often be scheduled in channel operations. However, when a requirement arose for unit moves of outsize cargo, such as the Patriots to Israel in January, the C-5 was assigned those missions. The C-141, being a somewhat less efficient bulk cargo carrier but a good oversize cargo aircraft, was used significantly less in channel operations.[46]

The regular, predictable nature of channel operations permitted the CRAF operators to achieve lower average ground times and to reduce the delays experienced. Further aiding the CRAF operations was the use of civil airfields for enroute stops. This combination of factors allowed CRAF to perform well.

"Inefficiencies" Dictated by Operational Needs

In some areas where performance fell below expectations, the reasons were dictated by higher-level operational requirements. One such operation was Desert Express. To create a more responsive logistics system for high-priority items, MAC established an express delivery service between Charleston Air Force Base and the theater. Items arriving at Charleston by 1700 hours would be delivered to units in the theater within 24 hours. Since flying time alone was roughly 17 hours, the pressures on the airlift system were substantial: loading, unloading, and enroute refueling, *if everything else went smoothly,* could not exceed seven hours. Desert Express missions had priority, which could delay other flights. C-141s would stand

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[45]Some of the delays associated with KC-10s are artificial. If the KC-10s were employed for fighter deployments and the fighters stopped enroute, the KC-10s would stay on the ground until the fighter pilots came out of crew rest, 12 hours later.

[46]KC-135 tanker airlift support figures were not maintained by SAC and the bulk of the support was carried out under SAC Opportune Airlift (the opportune airlift rules required higher headquarters' reporting only if non-SAC cargo/passengers were involved). One exception was a B-52 pipeline, operated by 8th AF/LG and consisting of two dedicated airlift flights per week. Between 20 January and 15 April 1991, Mighty Express airlifted 700 passengers and 3000 pieces of equipment, weighing a total of 200 tons.

alert to ensure that enough aircraft were available to make the deadline for the cargo sent. Sometimes missions would depart with less than full loads.

Similarly, MAC sought to reduce the length of time that cargo sat in the channel ports, so it would at times send missions with less than full loads if cargo had been sitting for too long. In yet another example, during February 1991, MAC withheld some C-141s for the medical evacuation (medevac) role in anticipation of the ground war. Fortunately, these aircraft saw little use.[47] However, on paper these aircraft would show up as available aircraft not used. In a narrow sense, these decisions led to "inefficiencies," but in the larger scheme they provided critical support to the theater.[48]

Sometimes, the MAC CAT deliberately accepted less than full use of aircraft as part of a larger operational concept. For instance, as shown earlier,[49] the average payload for narrow-body CRAF cargo aircraft achieved 58 percent of planning factor levels, while narrow-body CRAF passenger aircraft achieved 39 percent of their expected loads. These shortfalls can be explained by the operational concept in effect. MAC generally used these aircraft primarily for smaller requirements: small units or channels with little cargo or few passengers. Often, it did not make operational sense to have these aircraft stop elsewhere to pick up partial loads, splitting units or taking up valuable ramp space just to move a few more pallets. Instead, MAC determined that it was wiser to simply send the aircraft with what they had. Therefore, although this might appear at first glance to have been a significant inefficiency, in reality it seems to have been a wise operational choice.

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[47]A number of B-767s in CRAF are earmarked and equipped for the medevac role. However, at the time of ODS all these B-767s were in Stage III, which was not activated, and the airlines did not volunteer the aircraft. This forced MAC to convert some C-141s.

[48]Desert Express may also have helped to reduce the demands on the airlift system. By providing a means of rapidly bringing critical supplies from CONUS, it reduced the need for logisticians to anticipate requirements weeks or months ahead. It became a "pull" rather than a "push" logistical system. Since units could call for high-priority items as needed, they did not need to deploy a large number of stocks which they may or may not have ended up using. Some people disagree, arguing that demand will simply expand to whatever capability exists.

[49]See Figure 3.

One may also remember that the average passenger loads for C-5s and C-141s were well below planning factors: 22.7 versus 73 for the C-5 and 11.3 versus 22 for the C-141. These statistics could be influenced by the type of missions flown. For organic lifters, most passenger moves occurred during unit deployments. Commanders preferred to maintain unit integrity when possible and chose to leave with an airplane only partially full rather than take a few more soldiers and split up a unit.

Unit deployments accounted for 76 percent of all the passengers carried on C-5s and 94 percent carried on C-141s. Two factors account for this. First, most personnel deploy with their units, either flying with their equipment (especially for Air Force and light Army units) or in a passenger aircraft with other personnel from their unit (mostly Marine and heavy Army units). Relatively few moved on channel missions.[50] Second, in the case of the C-141, the passenger seats in a normal cargo configuration are found on the sidewalls. Occupying the seats can limit the amount of cargo that can fit in the aircraft. The C-5, in contrast, has separate seating in the upper compartment. Therefore, in channel operations, passengers would be moved on a C-5 or on a CRAF passenger aircraft rather than on a C-141. For these two reasons, one would expect to see lower average passenger loads on channel missions than on unit deployments. Table 11 presents these averages for the C-5 and C-141. The statistics show a slight difference. The C-5 carried roughly 50 percent more passengers on average on unit deployments, the C-141 100 percent.[51]

SUMMARY

This chapter discussed many factors that help explain why the airlift system performed less than optimally or at less than expected levels. Ideally, one would like to quantify these various explanations to de-

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[50]Overall, just under 60,000 people, 13 percent of all passengers, were moved in channel missions through the end of February. Over a fifth of these were in the final month of February.

[51]The high averages for the C-141 in December and January may be deceptive since some C-141s were converted to a passenger configuration in which they could carry 150 passengers.

Table 11

Average Passenger Loads: C-5 and C-141

Airlift	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall
Average Number of PAX over All Missions								
C-5	50.9	26.2	13.6	12.1	22.4	24.0	13.1	22.7
C-141	19.2	8.2	4.9	6.8	13.7	17.5	4.0	11.3
Average Number of PAX for Unit Moves								
C-5	51.4	27.4	18.8	22.6	27.2	22.7	14.9	27.6
C-141	18.7	8.1	6.4	13.0	20.9	21.6	4.5	14.1
Average Number of PAX for Channels								
C-5	38.2	21.8	7.3	8.1	17.4	27.3	11.0	18.7
C-141	25.4	9.7	1.7	2.3	3.3	6.5	3.0	7.4

SOURCE: MAC/XPY.

NOTE: Values are for 30-day months.

termine which were most important. Unfortunately, we have been unable to do this with the data at hand. For instance, we may know that the lack of a stage base constrained airlift operations. However, we cannot answer the question, "If that constraint had been lifted, what would have constrained the system next?" Too many overlapping factors conceal the true import of any one individual constraint. We have also found that the principal constraints varied over the course of the operation, or even day to day and hour to hour. The best we can offer is a list of these constraints with some idea of their impact.

These constraints may be summarized as follows:

- The lack of a stable, reliable requirement in the first weeks of the operation made it impossible to make efficient use of the airlift fleet.
- Many planners and users outside MAC did not understand the assumptions underlying planning factors and the fact that, given a different set of assumptions, the flow could change dramatically. Therefore, they built plans and prepared loads based on faulty expectations.
- Automated database processors and procedures often could not reliably keep up with the frequent changes made to the requirements. In some cases, the problems arose with old systems using slow, cumbersome technology; in other cases, the systems were too new to have been thoroughly debugged and to have sufficient numbers of people trained to use them. In addition, a number of deployment databases throughout the services had not been kept up to date, containing data on items no longer in the inventory while not containing information on new systems.
- The need to respond to rapidly evolving operational situations in the theater, albeit essential, meant that the airlift system performed at less than its theoretical optimum.
- The lack of a stage base at a time when aircrews were scarce could by itself explain a 20 to 25 percent shortfall in system performance.

- The inability of many deploying units to prepare cargo within the time assumed in planning factors meant that missions were delayed or postponed, reducing the utilization rate of the fleet.
- The relatively few enroute bases capable of handling the airflow made the entire system highly sensitive to any disruptions at those bases, such as weather, air traffic control, or ramp congestion.
- The heavy reliance on Dhahran as the primary offload base in the theater significantly reduced the throughput achievable. It also increased the sensitivity of the entire operation to problems there, such as limitations in the fuel system, ramp space constraints, and breakdown in MHE.
- Old MHE proved to be unreliable and frequently caused delays or limited throughput.
- The poorer-than-expected reliability of the C-5 significantly reduced its utilization level.
- Lower-than-expected payloads for the C-141—because of fatigue in the inner-outer wing joint of the aircraft—meant that the number of short tons moved per day was about 26 percent less than simple capability measures like ton-miles per day would suggest.
- Late and incomplete call-up of reserve crews meant that even if these other constraints had been resolved, full utilization of the fleet would not have been achieved.
- Some areas of apparently poor performance in fact reflect sensible operational decisions obscured in broad measures of efficiency. These include Desert Express, medevac withholds, and the use of narrow-body CRAF aircraft for smaller movements.

We will probably never know for certain how constraining each of these factors was on the overall airlift system. Yet the factors do answer some of the questions raised earlier. First, many of these constraints were beyond MAC's control. These include decisions made by the supported command (CENTCOM) on priorities or on base access, the activation of reserves, and the competency of units to prepare cargo. Second, the planners did not understand the assumptions underlying the planning factors, including ample time to

schedule, full availability of crews, and adequate basing, each of which fell short. Third, some of the planning factors were overly optimistic. Finally, problems with MHE, JOPES, and the C-141 had already been identified and were being addressed. No single explanation suffices to account for the various shortfalls experienced.

Chapter Four examines some of the issues that will be addressed in the near future. The final chapter offers some concluding recommendations.

Chapter Four

THE FUTURE

During our study, we were frequently asked about the implications of ODS for the future of strategic airlift. This chapter addresses some of the most important questions raised: the future of the C-141 and the C-17, the effect of base closures, and MHE modernization.[1]

C-141 LIFE

A question that arose frequently during the crisis was, "What effect did Operations Desert Shield and Desert Storm have on the service life of the C-141?" The fear had been that the increased flying rate—about three times higher than normal—would greatly accelerate the required retirement of the C-141 fleet. Reports of wing cracks, cracks around windshields, and cracks in the inner-outer wing joints heightened these concerns. To understand these issues, it helps to review briefly the background on C-141 service life.

When the Airlift Master Plan was published in 1983, MAC had been planning to keep 150 C-141s, without major upgrades, until 2010, and then retire the 150 by 2016. However, with the changing strategic mission in the 1980s, the C-141 began to be flown in more high-stress, low-level missions and aerial refueling training missions. The result was more fatigue hours per flight hour (up to 1.6 from about 1.1), wing cracks and corrosion, and cracks in the inner-outer wing

[1]Another major issue is the future of the CRAF program. Questions have arisen over the future viability of CRAF and the proper direction for the program to take. These questions are being addressed in other RAND studies.

joint area in over 100 aircraft. Before the start of Desert Shield, the Air Force had scheduled a program for FY91–FY94 to replace the center wing box; this would allow the C-141 to reach the projected service life of 45,000 fatigue hours.[2] MAC has also instituted a three-year depot repair/rework program to fix the wing cracks. In the interim, fleetwide operational restrictions, imposed during ODS, remain in effect.

Flying during ODS cost the C-141 about one year of its life, as can be seen in Figure 26.[3] The curves show the total aircraft inventory that can be retained, given the number of hours left on the fleet.[4] At first glance, this result might seem surprisingly low, given that the aircraft accrued three times more flying hours for the one-year period (August 1990 to July 1991) than normal. The reason for this relatively small effect was that MAC suspended the more stressful flight profiles—airdrop, low-level flying, and aerial refueling—typical in peacetime training. This normal peacetime flying leads to a fatigue severity factor of 1.6 (fatigue hours for each flight hour). In ODS, the rate was virtually one flying hour to one fatigue-life hour.

Does this one year make much difference? Figure 27 shows the planned force structure for the C-141 in terms of Primary Authorized Aircraft. To convert the TAI figure to PAA, we assumed that 88 percent of the total fleet is assigned to units (PAA).[5] The figure reflects a retirement schedule that was adjusted after the

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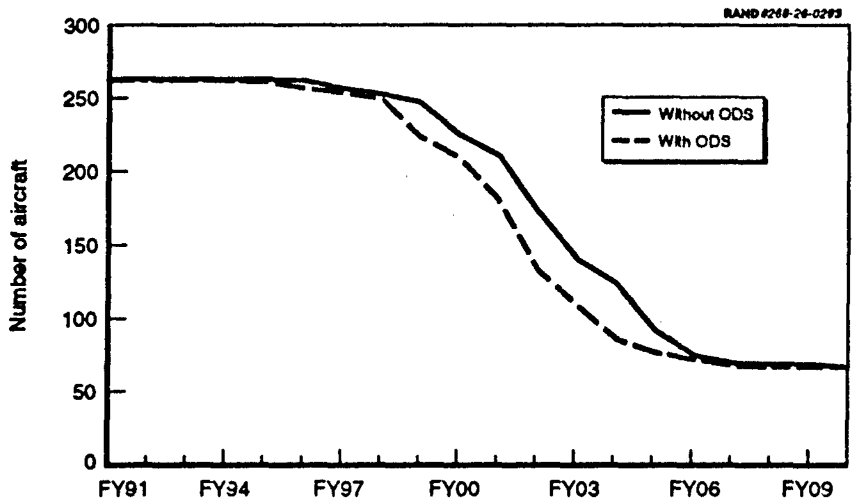
[2]The aircraft was designed for 30,000 fatigue hours, but in 1977 MAC concluded that this number could be increased to 45,000 if airframe use remained about the same and if structural modifications, inspections, and repairs were performed as necessary. The new center wing box is one of the conditional requirements for the C-141 service life to be extended to 45,000 hours, as is the inner-outer wing joint rework program. One hundred forty-seven TAI (total aircraft in inventory) [or 128 PAA (Primary Authorized Aircraft)] C-141s will go through the full upgrade.

[3]Military Airlift Command, "Point Paper: C-141 Service Life," 14 February 1991, Capt Ed Del Real, MAC/LEMWB.

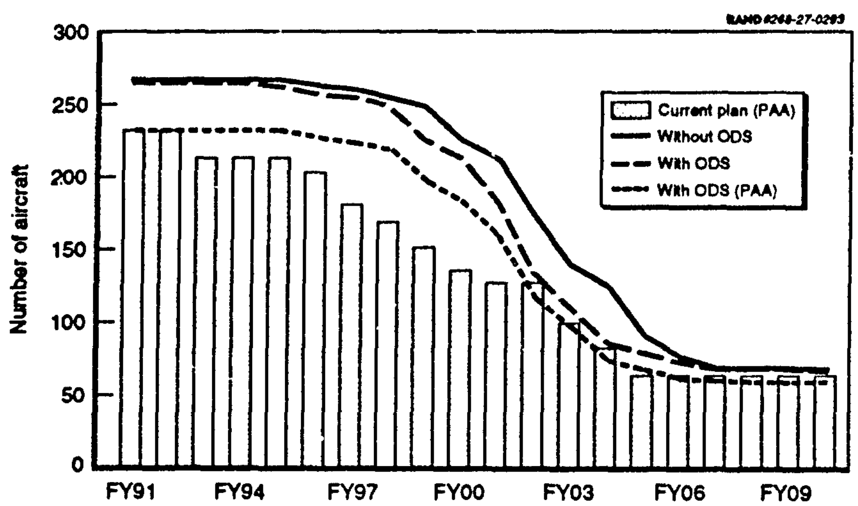
[4]The figure assumes that as the C-17 enters the force, the C-141 gradually lowers the number of annual flying hours (from 960 hours per year per aircraft in FY92–FY94 to 826 hours per year thereafter) as well as the severity of flying (the expected severity factor is 1.4 fatigue hours per flying hour).

[5]In 1990, 110 of 127 C-5s (87 percent) and 234 of 262 C-141s (89 percent) were PAA.



SOURCE: MAC/XPP

Figure 26—The Effect of ODS on C-141 Fatigue Life



SOURCE: MAC/XPP

Figure 27—C-141 Fatigue Life and Replacement Plans

war, and which continues to be adjusted, for FY02 and beyond.[6] Accelerating the retirement of the C-141, or, alternatively, reducing the number and severity of flying hours, reduces total force capability. If the C-17 is delayed in entering service, this problem will be exacerbated.

C-17

Another frequently asked question is, "Would the C-17 have made much of a difference in ODS?" Assuming that the C-17 meets its specifications[7] and that there are no crew constraints, it could provide significantly greater capability in a future ODS-like operation. First, the C-17 will replace the aging C-141, avoiding (it is hoped) the sort of operational limitations that have begun to plague the older aircraft. Second, the C-17 contract calls for substantially higher maintainability, which should mean fewer logistics delays and a higher percentage of aircraft available. Third, with its advanced thrust reversers, the C-17 will be able to make better use of constrained space on airfields and to decrease ground times; this will permit greater throughput when airbase access is limited. Finally, the C-17 would offer considerably more outsize capability.

To illustrate the potential contribution of the C-17, we estimated what the planned force for 2005 could have delivered under airbase constraints similar to ODS in August 1990 and under unconstrained

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[6]It appears that, even with the revised schedule, there are years in which the planned force ("Current Plan [PAA]") slightly exceeds the projected capability (aircraft inventory "With ODS [PAA]"). The data in Figure 26 were based on assumptions in February 1991 to project Desert Storm utilization/severity rates through September 1991; in fact, utilization rates decreased sooner and severity factors increased marginally. The net effect may be slightly different.

[7]The key specifications assumed here are a range-payload performance that permits payloads at least twice those of the C-141 in ODS (40 short tons), a higher UTE rate (15.2 hours per day), improved maintainability (permitting at least an 85 percent availability rate), and the ability to back up with a full load using engines alone. The C-17 performance specifications (from the C-17 System Operational Requirements Document [SORD]) has a similar payload; utilization (UTE) rates of 13.9 (sustained) and 15.65 (surge); mission capable rates of 92 percent (for a mature squadron with 100,000 cumulative fleet flying hours); and the ability to back up.

conditions.[8] See Figure 28. To make these estimates, we used the Airlift Cycle Assessment System (ACAS), a spreadsheet model developed at MAC for simple airlift calculations. The 2005 fleet consists of 102 PAA C-17s (102 PAA is equivalent to 120 TAI, the planned C-17 buy), 110 C-5s, 64 C-141s, and CRAF Stage II as it existed at the time of ODS. For the sake of comparison, we have also included a case with an additional buy of 120 C-5Bs instead of 120 C-17s, and a case using CRAF Stage III to replace the C-141 fleet.[9] The constrained case comes closest to the real situation of August 1990; the estimated capability is less than 3 percent higher than the actual average for the first 30 days. As can be seen, the C-17 would provide significantly greater capability in an ODS-like scenario, 30 percent more than the 1990 fleet. In the unconstrained case, the C-17 still provides more capability, although the use of CRAF Stage III would equal it in simple terms of short tons deliverable; however, the CRAF option would supply far less oversize and outsize capability. The C-5 option performs badly because, using ODS experience, its availability rate is quite low[10] and the average payload is only 60 short tons. This analysis suggests that, if the C-17 lives up to its promise, it could offer substantially greater capability under a wide range of conditions.

LOSS OF ENROUTE BASES

The airlift to the Gulf relied heavily on the facilities provided by Torrejon, Rhein-Main, and Zaragoza. These three bases supported

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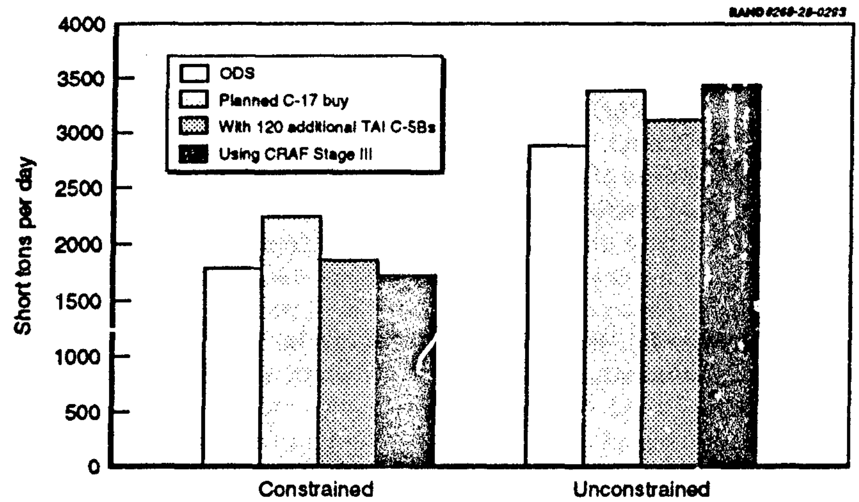
[8]The constrained case assumes a maximum-on-ground (MOG) constraint of 10 C-5s or 16 C-141s, roughly equivalent to having access to Dhahran and Jubail. The unconstrained case assumes unlimited MOG. No crew constraints are used. Average payloads and mission-capable rates from ODS and a 10-percent withhold are applied. C-17 performance assumes a MOG of 26 for the constained case (based on parking rather than refueling space constraints), a UTE rate of 15.2, a mission-capable rate of 85 percent, and an average payload of 40 short tons.

[9]These calculations do not include cost estimates; they are merely a comparison of roughly similar capabilities or numbers of aircraft, using broad planning factors.

[10]The C-5 option arbitrarily assumes that new C-5s *would* be slightly better, achieving a 80 percent mission-capable rate. However, the fleetwide average would still be only 75 percent.



SOURCE: ACAS

Figure 28—What the C-17 Could Have Provided

61 percent of the entire airlift flow. Zaragoza is no longer available to AMC. Access to Torrejon after FY94 is questionable, and Headquarters USAFE is facing increased pressure to either close or reduce operations at Rhein-Main.[11] Replacement bases need to be big enough to support large airlifters and large volumes of traffic, they should have the necessary infrastructure, and they should be properly situated. This is a difficult set of requirements to meet. AMC has placed a high priority on keeping Rhein-Main open and in seeking an agreement with Spanish authorities about use of Torrejon in a crisis.

MATERIAL-HANDLING EQUIPMENT

As described in the previous chapter, aging MHE was a recurring problem. MAC had known of this problem, and had funded a program to replace the existing MHE—25K and 40K loaders and wide-

[11]Similarly, Clark Air Force Base in the Philippines, which would have been the primary strategic airlift base for contingencies in the Asia-Pacific region, has been closed.

body loaders—with a single modern system: the 60K loader. The 60K loader can handle more than two times the cargo as the 25K loader and one and one-half times as much cargo as the 40K loader and can be elevated for use with wide-body civil aircraft. It should be more maintainable than the existing loaders. Finally, it should be significantly more deployable. The old loaders required six hours to assemble and four hours to disassemble; the 60K loader will require only one hour foi each operation, thus increasing its availability. The only question remaining is whether enough 60K loaders will be procured to support operations, especially if the C-17 manages to increase operational tempos with its higher utilization rate and larger payload.

BETTER PREPARED IN THE FUTURE?

Finally, one is left with an intangible but real side effect of the successful Gulf airlift. We have learned invaluable lessons in a host of areas. In any fuiure contingency, we should be better prepared to plan and execute an airlift operation of this scale. The Air Mobility Command now has personnel thoroughly experienced in the reality of large-scale operations. They will carry these experiences with them, and undoubtedly will institute reforms and institutionalize successes learned from the Gulf airlift. But that is dependent upon ensuring that these skills and lessons are not lost.

Chapter Five

OBSERVATIONS AND RECOMMENDATIONS

This chapter uses the implications of the Operation Desert Shield and Desert Storm experience to make some specific observations and recommendations. Airlift is a system, and all components of the system need to be considered if the whole is to be improved. As before, we have categorized these components under the headings of planning, bases, aircrews, and the aircraft fleet.

PLANNING

Transporters Should Be More Involved in Close-Hold Planning

Many of the problems cited in the early days of the deployment could have been avoided or alleviated if transporters had been more thoroughly involved in the close-hold planning[1] prior to C-Day, the day on which movement began. Obviously, leaders must limit access to highly sensitive planning. However, because the options being considered centered largely on deployment of forces, it would have been preferable to have knowledgeable transporters—airlift, sealift, and ground transportation planners or operators—to provide the basis for making feasible transportation plans. In turn, transporters on the joint staffs, particularly those privy to the close-hold committees, need to ensure that they can contribute to the planning process by offering responsive, analytic capabilities. Finally, Headquarters

[1]See Chapter Two, Pre-Crisis Preparations.

TRANSCOM and Headquarters AMC personnel should be brought in as early as possible to validate the transporters' assumptions and planning factors.

Planning Factors Must Be More Realistic and Better Explained

The deployment community should reassess the planning factors used. Deployment community assumptions about time lines for crisis planning seem unrealistic. Rather than an orderly progression of establishing requirements, making transportation-feasible plans, and executing those plans, we may more realistically expect crises like ODS, where events happen simultaneously.

Realizable numbers rather than overly optimistic numbers should constitute the data in the planning factors. Even before directives during ODS to lighten the loads, for example, average C-141 payloads were lighter than what planning factors called for.[2] A number of hypotheses were given in our investigation of the reason why the loads were lighter than anticipated, and the official explanation does not nullify these theories (many of which were heard repeatedly). Planning factors, while indicating how much weight an aircraft can carry, for instance, may not realistically reflect other constraints, such as environmental considerations or lighter-than-anticipated loads.

Payload estimates for the C-141 need to be reconsidered, given the recent restrictions. Planning factors should be constantly reappraised and updated, so that reasonable predictions of throughput can be made. Mission-capable rates and utilization rates also warrant a relook.

Documents setting forth planning factors and guidelines should state explicitly the assumptions that underlie them and how changes in the assumptions might affect the result. One cannot publish all pos-

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[2] In the Bright Star exercise in 1987, the average C-141 payload was 19.1 short tons. In the same exercise in 1989, the payload was 16.8 short tons (the aircraft flew a longer distance, travelling down the Red Sea). In other exercises (Team Spirit in 1987 and 1989, and Reforger in 1987) the C-141's payloads were again significantly less than planning factors might suggest.

sible variations, but mentioning the problem could help users and planners understand the problems that could arise and perhaps seek guidance.

Reconsider Planning Around Optimality

The disconnect between the near-perfect world assumed in deliberate scheduling and the experience of ODS might be narrowed if AMC were to give typical performance factors in its planning factors, while including theoretic maximums and noting that they are feasible. This would motivate the planners and users to attend to all elements of the system.

Reassess Channels of Communication

The Requirements Augmentees were effective in establishing airlift requirements and in passing information to users when automated systems failed. Normally, communication does not flow directly between transporter and user, and staff at TRANSCOM were unsettled by the deviation. However, this line of communication was successful, even critical, and direct communication should be authorized by being institutionalized.

Planning Tools Must Be More Flexible

Probably the biggest impediment to the optimal operation of the mobility system during the Operation Desert Shield deployment was the inability of planners to respond rapidly to the initial deployment order, and then later to the numerous changes in priorities and schedules that followed and persisted. AMC needs a rapid planning capability from the start, when courses of action are selected by the close-hold planning group, and subsequently, in response to a fluid situation. There need to be data systems and tools that support this philosophy. There also need to be good interfaces between the joint data systems, like JOPES, and the airlift planning and employment data systems.

RAND is exploring these issues in other work. One concept under discussion is an "Airlift Flow Package" consisting of a modular, pre-

planned flow of aircraft to transport a specific unit, under a specific set of assumptions. Although there are disadvantages to prepackaged loads,[3] there are also disadvantages in investing effort in planning schemes that are heavily reliant on specific scenarios. With the flow modules or similar, more flexible tools, AMC could reassemble a database relatively quickly when the inevitable changes began.

Establish Redeployment Offices

For large-scale deployments, serious planning for the eventual redeployment of forces must be accomplished early. As described above, planning for a redeployment is not the same as planning for the original deployment. We recommend that as part of standard procedures for major deployments the supported command establish an office with specific responsibility for coordinating redeployment activities to permit the orderly and timely removal of forces from a theater. That office would establish priorities and procedures, and would communicate them to commanders and units before the end of hostilities. It would also coordinate incoming sustainment missions and outgoing redeployments. Orderly redeployment procedures would be especially important if the United States should ever face two contingencies in sequence, requiring it to redeploy forces from one theater to another. As the United States reduces its force structure, at least some forces for a second contingency will almost certainly need to come from forces used in the first.

BASES

Need Single Transportation Point of Contact at Each Base

The problems encountered at many onload bases could have been lessened if everyone knew to whom to talk. The Requirements Augmentees in the MAC CAT often had to call a dozen or more peo-

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[3]Opponents to prepackaged moves claim that in the theater other pressures like host nation support, ramp space, and number of available airfields determine what is required, and the available prepackaged options may not satisfy the conditions. The result is improperly positioned equipment.

ple at a base before they could find the person who—maybe—knew about mobility operations. The problem was magnified when more than one unit was stationed at that base. It would be advisable to establish a single point of contact at every base—a person or office—that would be the clearinghouse and coordinator for transportation.

Need MHE Modernization and War Reserve Stock Kits (WRSK)

AMC has recognized the need to procure the new 60K loaders and to develop WRSK for its MHE. The Air Force and the joint community should ensure that these programs remain a high priority. For relatively small budgets they will provide important capability to all the services.

Aerial Refueling of Airlifters Could Offer More Utility

Aerial refueling could have been used more extensively, allowing more planes to cycle through a base in a given amount of time and reducing the MOG. The airlift system needs to be able to identify which aircraft have air-refueling-qualified crews on board—a capability that would require software modifications. Better communication channels need to be established. Tanker schedules need to be able to withstand some amount of receiver delay, since airlifters can be delayed by many factors outside of AMC's control. RAND is exploring, in other work, what constitues a permissible "window" for airlifter arrival times, in terms of tanker scheduling and competing demands on the tanker force. One option is to dedicate a portion of the tanker fleet to airlift support.

Training Is Necessary for High-Volume Stage Operations

MAC used to run a stage operation in Europe for crews on peacetime channel missions. The fact that it had stopped was evident by the lack of experience and subsequent disarray in the high-volume stage operations during Operation Desert Shield. AMC needs to provide manuals and training to command-post personnel.

Assure Access to Torrejon and Rhein-Main

The Gulf War airlift proved the importance of large, capable enroute bases to support massive airlifts. Three critical bases have closed or are under increased pressure to close. Rhein-Main was critical in terms of tonnage moved, although it is possible that MAC could have moved it elsewhere. What happens to Rhein-Main could influence how Ramstein is used in the future. Future planning should extend to basing in England but, depending where the APOD is, it is possible that crew rest problems will occur.

Enroute bases are not simply an airlift problem. The entire military depends on the capability these bases provide. The absence of reliable access to good facilities could adversely affect combat operations. The U.S. government needs to make appropriate agreements with its allies to ensure the maintenance of key bases and quick access in a crisis. However, we should also bear in mind that access to a base is not as good as control of a base, and reduced throughput is likely if the United States does not have control.

AIRCREW AVAILABILITY

Crew Management Needs More Attention

Crew management was a real problem, with individual members of crews running out of flying hours mid-mission and pervasive mismatches between qualifications needed and qualifications available. Some of this was out of MAC's control, but some changes are possible.

Automated data processors need to be able to track data on individual crew members. The system should know what people are at which base, or in which aircraft; how many flying hours they have accumulated and have remaining; and whether they have special qualifications such as airdrop or aerial refueling.

AMC Needs a Stage Base in the Theater

A stage base in the theater would have reduced the pace at which crews burned up their monthly flying-hour limits. AMC needs to ed-

ucate senior leadership on the criticality of this being provided in future operations.

Reductions in Airlift Crew Ratios Are Ill-Advised

Given the severe crew shortages that developed early in ODS, it appears unwise to reduce crew ratios below existing levels. Reducing aircrews will mean reducing airlift capability. Lowering crew ratios will mean having too few crews available to fly the airplanes at the UTE rates.[4] It seems unsound to buy a major new airlifter while reducing the capability of the fleet. Similarly, the Air Force should be reluctant to move any additional crews or strategic airlift capability into the reserve component unless it can be assured rapid access to those crews. In any major deployment, the full airlift capability would be needed in the early days of operations. Moving crews to the reserves has the potential to reduce our ability to deploy combat forces rapidly.

COAMC Should Have Limited Call-Up Authority

One of the first significant constraints on airlift operations was the shortage of aircrews. This problem will be compounded with the political decision to put more assets in the reserves. We recommend that the Defense Department explore the idea of granting COAMC limited call-up authority in times of transportation emergencies. Currently, COAMC has the authority to activate CRAF Stage I by declaring such an emergency, but he cannot gain access to his own reserve aircrews. All too often U.S. planning scenarios assume that there will be sufficient time to call up reserves before committing to

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[4]RAND considered representative Major Regional Contingencies (MRCs) to the east and west; for basic crews (two pilots) versus augmented crews (three pilots); and with normal, 30-day, crew duty limits (125 hours) versus extended, 30-day limits (150 hours).

Today the crew ratio is 3.2 for the C-141 and 3.0 for the C-5. Lower crew ratios are viable for ODS-like utilization rates. However, it appears not to be possible, today, to achieve *planned surge or sustained* utilization rates if augmented crews are being used. For basic crews to maintain *surge* condition UTE rates, the 30-day crew duty limit would need to be extended. We conclude that there is no room for crew ratio reductions.

deploy forces. In our opinion, the experience of Desert Shield is more likely the model of the future rather than the exception. Current initiatives such as the Ready Mobility Force (RMF) recognize that something below presidential call-up is needed, and put it at the Secretary of Defense level.[5]

THE AIRLIFT FLEET

C-141 Replacement Is Essential

The C-141 is nearing the end of its service life. If the United States wishes to maintain the capability to conduct an ODS-size deployment in the future without crippling the civil sector, it needs to modernize its fleet. If the C-17 program continues on course, the issue can probably be put to rest. If, however, it does not continue, some other solution needs to be found.

More Outsize Capability Is Needed

Overall in ODS, only a small percentage of all cargo—11 percent—was outsize cargo. Given that a third of the U.S. organic fleet is outsize capable (the C-5s), one might conclude that additional outsize capability is unnecessary. The experience of ODS suggests otherwise. First, the C-5 has been plagued with disappointing reliability; on average, only 68 percent were available at any given time; sometimes as few as 50 percent were available. With a cycle time from CONUS to the Gulf of about three days, and with only 68 percent of the fleet available, there would be only 25 C-5s a day to pick up new loads. It takes about 25 C-5s to move one Patriot battery. Second, although the overall percentage of outsize cargo was low, at certain critical times the demand for outsize cargo grew very intense. The deployment of Patriots to Israel and Turkey and HETs to Saudi Arabia in late January–early February was just such a period. For those critical weeks, the demand for C-5s exceeded the fleet's capability. Third, the C-5 requires a great deal of ramp space and runway length to operate, and it can take a long time to load and unload

[5]The Ready Mobility Force initiative is being looked at by both active duty and reserve component staffs. It may be forwarded to Congress in the early spring.

given its large capacity. Even the largest airfields can become quickly saturated with C-5s. It was fortunate in ODS that we had access to large airfields. In the future, we might be forced to use smaller fields where operations would be far more disrupted by the arrival of one or two C-5s. The C-17, if it meets its expectations, could provide that capability.

Viability of CRAF Should Be Ensured

ODS proved the value of CRAF. At a critical moment, it augmented the organic military fleet with much-needed wide-body passenger aircraft and efficient bulk carriers. The use of the passenger aircraft permitted the rapid deployment of a large number of personnel, such as the Marine Expeditionary Brigades and the 24th Mechanized Division, in a matter of days. Although organic airlift could have performed the mission, it would have meant that other, critical deployments would have been postponed. CRAF aircraft in channel missions also freed up many organic airlifters to move the more difficult oversize and outsize equipment. The problems and potential of CRAF are explored more fully elsewhere. From a perspective of operational efficiency, CRAF clearly contributes a vital, complementary capability that the United States needs to ensure will continue.

CONCLUDING OBSERVATION

Airlift provides an essential capability, allowing the United States to respond quickly and decisively to crises around the world. In ODS, it permitted the rapid and massive deployment of combat forces that deterred Saddam Hussein from further aggression. This capability is unique in the world, providing the flexibility necessary to operate effectively, even without a significant forward presence.

ODS also proved that airlift is a system. To maintain this critical capability, we must keep all the components of that system in balance and in good health.

Appendix A

STATISTICAL SUMMARIES

In the course of our study, we were frequently asked to provide statistics on various aspects of the strategic airlift in Operation Desert Shield. Because of the interest in the data, we include some of the more useful statistics here. Many of these tables repeat information in the main text but are included here for completeness. Entirely new to this appendix is a summary by user—Army, Air Force, Navy/Marine Corps, CENTCOM, Channel, and MAC.

ODS Airlift Statistics by Aircraft Type

Table A.1

Overall Missions by Aircraft Type

Aircraft Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
C-5	397	510	437	416	570	680	552	3,562
C-141	967	998	682	710	1,399	1,639	1,457	7,852
Narrow body: Cargo	60	86	45	91	154	289	346	1,071
Narrow body: PAX	3	9	8	9	11	40	47	127
Wide body: Cargo	21	93	51	71	112	200	279	827
Wide body: PAX	88	121	145	44	281	246	109	1,034
KC-10	17	88	55	50	115	48	0	373
Total	1,553	1,905	1,423	1,391	2,642	3,142	2,790	14,846

Table A.2

Average Daily Missions by Aircraft Type

Aircraft Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
C-5	13	17	15	14	19	23	18	17
C-141	32	33	23	24	47	55	49	37
Narrow body: Cargo	2	3	2	3	5	10	12	5
Narrow body: PAX	0	0	0	0	0	1	2	1
Wide body: Cargo	1	3	2	2	4	7	9	4
Wide body: PAX	3	4	5	1	9	8	4	5
KC-10	1	3	2	2	4	2	0	2
Total	52	64	47	46	88	105	93	71

Table A.3

Cargo: Average Short Tons by Aircraft Type

Aircraft Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
C-5	58.3	63.5	59.8	63.1	60.2	62.6	60.8	61.3
C-141	19.1	19.3	17.7	18.2	18.7	19.2	19.7	19.0
Narrow body: Cargo	29.4	27.1	27.9	22.2	20.8	22.3	23.8	23.6
Narrow body: PAX	19.7	20.1	12.0	15.0	14.1	11.2	9.3	11.9
Wide body: Cargo	69.7	75.6	77.4	82.1	71.8	72.8	71.1	73.4
Wide body: PAX	51.4	48.6	37.4	43.2	52.0	47.9	48.5	47.8
KC-10	32.1	39.2	33.6	33.2	29.9	28.0	0.0	32.9

Table A.4

Cargo: Total Short Tons by Aircraft Type

Aircraft Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
C-5	23,145	32,385	26,133	26,250	34,314	42,568	33,562	218,356
C-141	18,470	19,261	12,071	12,922	26,161	31,469	28,703	149,058
Narrow body: Cargo	1,764	2,331	1,256	2,020	3,203	6,445	8,235	25,253
Narrow body: PAX	59	181	96	135	155	448	437	1,511
Wide body: Cargo	1,464	7,031	3,947	5,829	8,042	14,560	19,837	60,710
Wide body: PAX	4,523	5,881	5,423	1,901	14,612	11,783	5,287	49,410
KC-10	546	3,450	1,848	1,660	3,439	1,344	0	12,286
Total	49,971	70,519	50,774	50,717	89,926	108,617	96,060	516,582

Table A.5

Cargo: Distribution of Effort by Aircraft Type (Percent)

Aircraft Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
C-5	46	46	51	52	38	39	35	42
C-141	37	27	24	25	29	29	30	29
Narrow body: Cargo	4	3	2	4	4	6	9	5
Narrow body: PAX	0	0	0	0	0	0	0	0
Wide body: Cargo	3	10	8	11	9	13	21	12
Wide body: PAX	9	8	11	4	16	11	6	10
KC-10	1	5	4	3	4	1	0	2

Table A.6

Cargo: Daily Short Tons by Aircraft Type

Aircraft Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
C-5	772	1,080	871	875	1,144	1,419	1,119	1,040
C-141	616	642	402	431	872	1,049	957	7[illegible]0
Narrow body: Cargo	59	78	42	67	107	215	274	120
Narrow body: PAX	2	6	3	5	5	15	15	7
Wide body: Cargo	49	234	132	194	268	485	661	289
Wide body: PAX	151	196	181	63	487	393	176	235
KC-10	18	115	62	55	115	45	0	59
Total	1,666	2,351	1,692	1,691	2,998	3,621	3,202	2,460

Table A.7

PAX: Average by Aircraft Type

Aircraft Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
C-5	50.9	26.2	13.6	12.1	22.4	24.0	13.1	22.7
C-141	19.2	8.2	4.9	6.8	13.7	17.5	4.0	11.3
Narrow body: Cargo	0.1	0.0	0.0	0.2	0.6	1.5	0.6	0.7
Narrow body: PAX	138.3	127.0	44.1	69.3	66.2	66.8	57.7	68.1
Wide body: Cargo	1.3	0.4	0.0	0.0	0.0	0.1	0.1	0.1
Wide body: PAX	355.6	309.4	277.8	273.8	276.9	276.3	253.9	284.8
KC-10	6.0	1.3	1.7	2.7	4.6	2.6	0.0	2.9

Table A.8

PAX: Total by Aircraft Type

Aircraft Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
C-5	20,207	13,362	5,943	5,034	12,768	16,320	7,231	80,865
C-141	18,566	8,184	3,342	4,828	19,166	28,683	5,828	88,597
Narrow body: Cargo	6	0	0	18	92	434	208	758
Narrow body: PAX	415	1,143	353	624	728	2,672	2,712	8,647
Wide body: Cargo	27	37	0	0	0	20	28	112
Wide body: PAX	31,293	37,437	40,281	12,047	77,809	67,970	27,675	294,512
KC-10	102	114	94	135	529	125	0	1,099
Total	70,617	60,278	50,012	22,686	111,093	116,223	43,682	474,589

Table A.9

PAX: Distribution of Effort by Aircraft Type (Percent)

Aircraft Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
C-5	29	22	12	22	11	14	17	17
C-141	26	14	7	21	17	25	13	19
Narrow body: Cargo	0	0	0	0	0	0	0	0
Narrow body: PAX	1	2	1	3	1	2	6	2
Wide body: Cargo	0	0	0	0	0	0	0	0
Wide body: PAX	44	62	81	53	70	58	63	62
KC-10	0	0	0	1	0	0	0	0

Table A.10

PAX: Daily by Aircraft Type

Aircraft Type	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
C-5	674	445	198	168	426	544	241	385
C-141	619	273	111	161	639	956	194	422
Narrow body: Cargo	0	0	0	1	3	14	7	4
Narrow body: PAX	14	38	12	21	24	89	90	41
Wide body: Cargo	1	1	0	0	0	1	1	1
Wide body: PAX	1,043	1,248	1,343	402	2,594	2,266	923	1,402
KC-10	3	4	3	5	18	4	0	5
Total	2,354	2,009	1,667	756	3,703	3,874	1,456	2,260

ODS Airlift Statistics by User

Table A.11

Missions by User

User	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
Army	677	632	416	241	747	838	506	4,057
USAF	382	670	355	140	321	530	564	2,962
Navy/MC	374	221	88	79	332	385	216	1,695
CENTCOM	29	90	7	13	25	171	57	392
Channel	8	265	552	885	1,098	1,122	1,361	5,291
MAC	83	27	5	33	119	96	86	449
Total	1,553	1,905	1,423	1,391	2,642	3,142	2,790	14,846

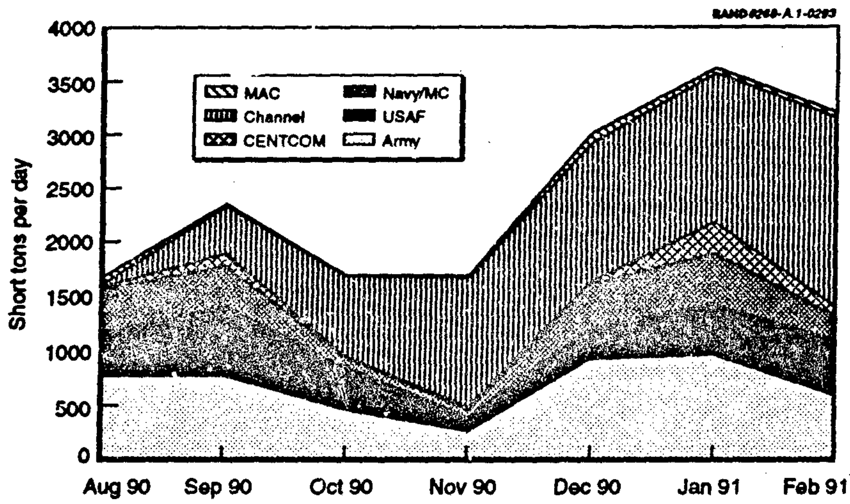


Figure A.1—Average Short Tons per Day by User

Table A.12

Cargo: Total Short Tons by User

User	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
Army	23,153	23,258	14,144	8,580	28,162	28,995	18,418	144,710
USAF	11,995	19,028	11,751	3,962	8,410	13,939	14,833	83,918
Navy/MC	11,818	11,161	2,666	1,975	11,388	13,475	6,739	59,222
CENTCOM	699	3,141	158	283	808	8,892	2,035	16,015
Channel	251	13,330	21,914	35,046	38,430	42,075	52,671	203,717
MAC	1,967	559	137	901	2,820	1,229	1,402	9,014
Total	49,864	70,476	50,769	50,747	90,018	108,605	96,098	516,596

Table A.13

Cargo: Average Short Tons by User

User	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
Army	34.2	36.8	34.0	35.6	37.7	34.6	36.4	35.7
USAF	31.4	28.4	33.1	28.3	26.2	26.3	26.3	28.3
Navy/MC	31.6	50.5	30.3	25.0	34.3	35.0	31.2	34.9
CENTCOM	24.1	34.9	22.5	21.8	32.3	52.0	35.7	40.9
Channel	31.4	50.3	39.7	39.6	35.0	37.5	38.7	38.5
MAC	23.7	20.7	27.3	27.3	23.7	12.8	16.3	20.1
Total	32.1	37.0	35.7	36.5	34.1	34.6	34.4	34.8

Table A.14

Cargo: Daily Average Short Tons by User

User	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
Army	772	775	471	286	939	966	614	689.1
USAF	400	634	392	132	280	465	494	399.6
Navy/MC	394	372	89	66	380	449	225	282.0
CENTCOM	23	105	5	9	27	296	68	76.3
Channel	8	444	730	1168	1281	1403	1756	970.1
MAC	66	19	5	30	94	41	47	42.9
Total	1,663	2,349	1,692	1,692	3,001	3,620	3,203	2,460.0

Table A.15

Cargo: Allocation of Effort by User (Percent)

User	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
Army	46	33	28	17	31	27	19	28
USAF	24	27	23	8	9	13	15	16
Navy/MC	24	16	5	4	13	12	7	11
CENTCOM	1	4	0	1	1	8	2	3
Channel	1	19	43	69	43	39	55	39
MAC	4	1	0	2	3	1	1	2

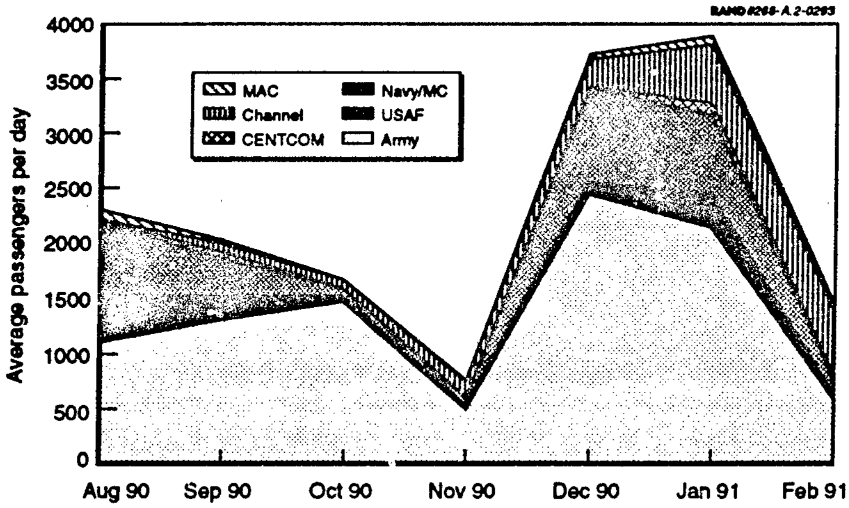


Figure A.2—Average Daily Passengers by User

Table A.16

PAX: Total by User

User	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Total
Army	32,767	38,805	43,971	14,725	72,683	63,688	17,558	284,197
USAF	12,835	6,365	1,420	1,344	3,563	9,487	1,297	36,312
Navy/MC	19,523	10,498	2,279	1,675	25,730	21,329	4,255	85,289
CENTCOM	664	1,503	90	459	285	3,164	1,037	7,202
Channel	84	2,624	2,208	4,160	7,576	16,157	17,149	49,957
MAC	2,864	437	30	284	1,273	2,371	2,365	9,624
Total	68,736	60,231	49,999	22,646	111,111	115,196	43,662	472,580

Table A.17

PAX: Average by User

User	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
Army	48.4	61.4	105.7	61.1	97.3	76.0	34.7	70.1
USAF	33.6	9.5	4.0	9.6	11.1	17.9	2.3	12.3
Navy/MC	52.2	47.5	25.9	21.2	77.5	55.4	19.7	50.3
CENTCOM	22.9	16.7	12.9	35.3	11.4	18.5	18.2	18.4
Channel	10.5	9.9	4.0	4.7	6.9	14.4	12.6	9.4
MAC	34.5	16.2	6.0	8.6	10.7	24.7	27.5	21.4
Total	44.3	31.6	35.1	16.3	42.1	37.0	15.6	31.8

Table A.18

PAX: Daily Average by User

User	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
Army	1092.2	1293.5	1465.7	490.8	2422.8	2122.9	585.3	1353.3
USAF	427.8	212.2	47.3	44.8	118.8	316.2	43.2	172.9
Navy/MC	650.8	349.9	76.0	55.8	857.7	711.0	141.8	406.1
CENTCOM	22.1	50.1	3.0	15.3	9.5	105.5	34.6	34.3
Channel	2.8	87.5	73.6	138.7	252.5	538.6	571.6	237.9
MAC	95.5	14.6	1.0	9.5	42.4	79.0	78.8	45.8
Total	2,291	2,008	1,667	755	3,704	3,873	1,455	2,250

Table A.19

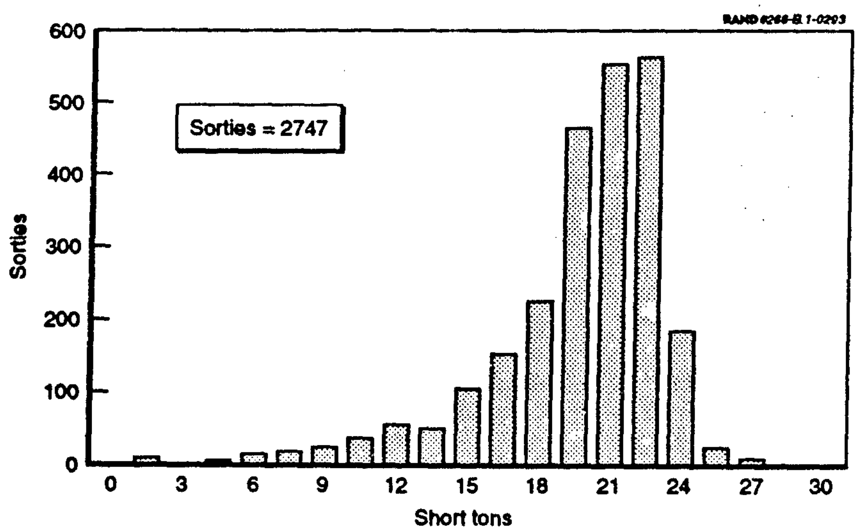
PAX: Allocation of Effort by User (Percent)

User	Aug 90	Sep 90	Oct 90	Nov 90	Dec 90	Jan 91	Feb 91	Overall Average
Army	48	64	88	65	65	55	40	60
USAF	19	11	3	6	3	8	3	8
Navy/MC	28	17	5	7	23	18	10	18
CENTCOM	1	2	0	2	0	3	2	2
Channel	0	4	4	18	7	14	39	11
MAC	4	1	0	1	1	2	5	2

Appendix B

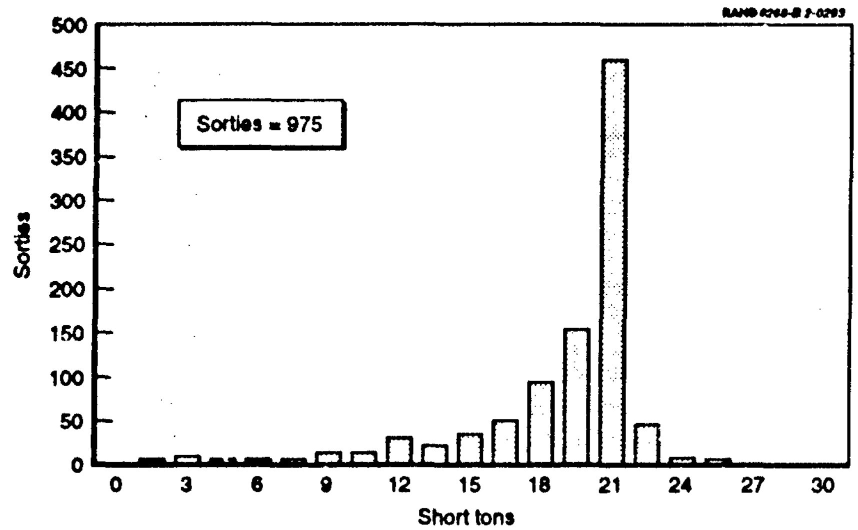
C-141 PAYLOAD DISTRIBUTION BY BASE

Appendix B shows the distribution of payloads by base for the seven busiest bases, representing 67 percent of all the sorties from CONUS. The bases are presented in descending order of number of sorties. As can be seen, the bases which exhibit the sharpest limits are the East Coast airbases: McGuire, Dover, Pope, and Charleston. The further south the base, the lighter the average payload and the more skewed the distribution is to the left. The western bases have much heavier average payloads and a more naturally shaped distribution, which suggests that we may be capturing some sorties that remained within CONUS.



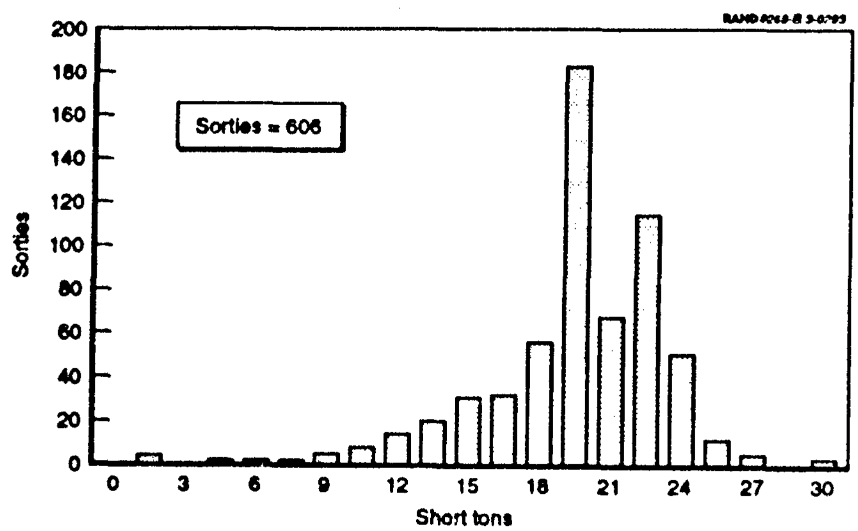
SOURCE: MAIRS

Figure B.1—C-141 Payloads at McGuire AFB



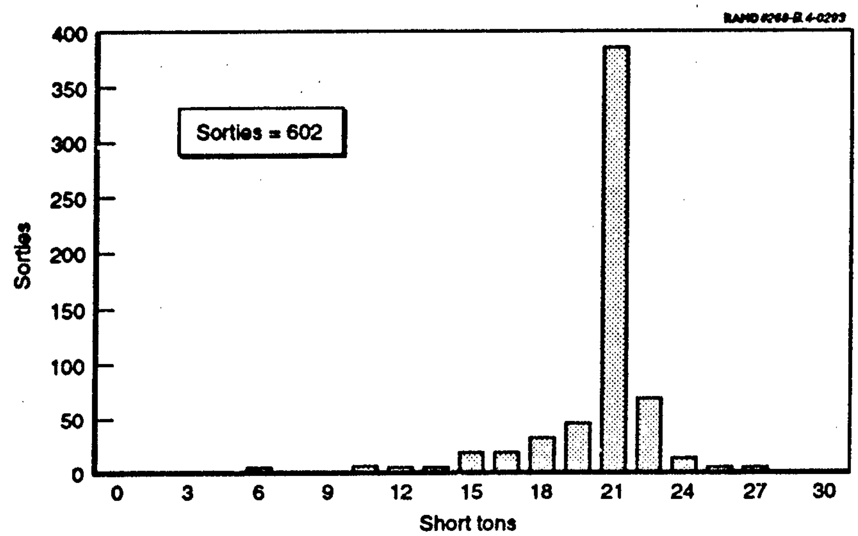
SOURCE: MAIRS

Figure B.2—C-141 Payloads at Dover AFB



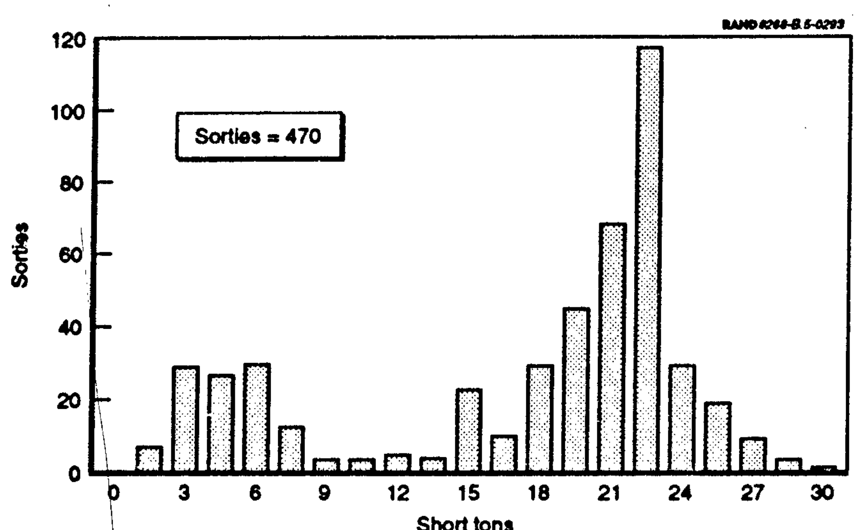
SOURCE: MAIRS

Figure B.3—C-141 Payloads at Tinker AFB



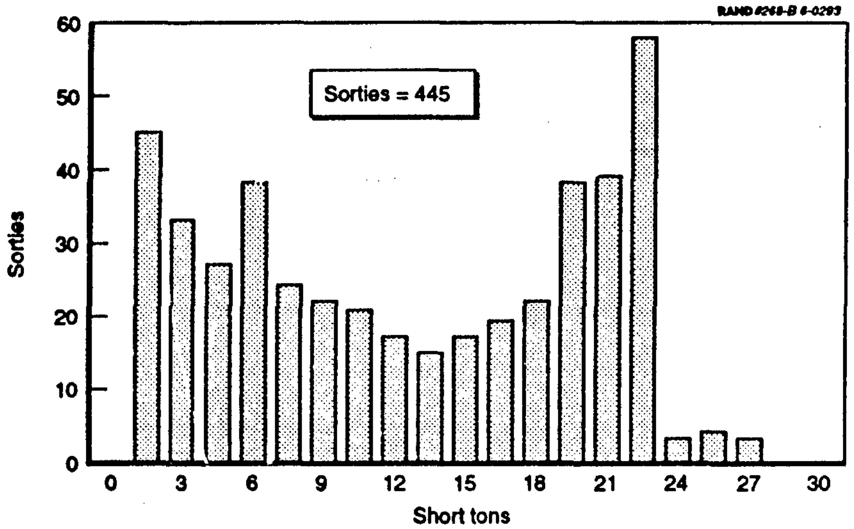
SOURCE: MAIRS

Figure B.4—C-141 Payloads at Pope AFB



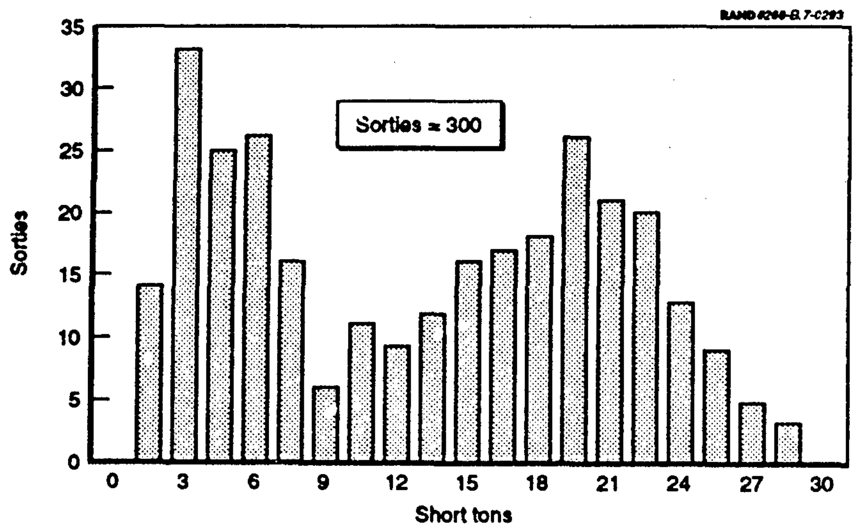
SOURCE: MAIRS

Figure B.5—C-141 Payloads at Norton AFB



SOURCE: MAIRS

Figure B.6—C-141 Payloads at Charleston AFB



SOURCE: MAIRS

Figure B.7—C-141 Payloads at Travis AFB

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